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LAUNCHING LATIN AMERICA: INTERNATIONAL AND DOMESTIC FACTORS IN NATIONAL SPACE PROGRAMS

by

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This thesis seeks to understand the internal motivations driving some Latin American countries to pursue space programs, how these programs interact at the regional level, and how countries with more developed space capabilities influence these efforts. This thesis also provides insight on the following questions: What obstacles have impeded the development of Latin American space capabilities thus far, and what are the prospects for future regional and international cooperation? This thesis finds that domestic politics matter most when determining the regional and international orientation of these space programs. Domestically, the desire to develop economically is the fundamental driver. While the era of military rule encouraged geopolitical competition among some of these programs, this faded after the return to democracy. Space now competes poorly with other social and developmental priorities due to a lack of electoral incentives for politicians. International collaboration is restricted by nuclear and missile nonproliferation regimes. U.S. export control regulations limit the scope of potential projects that might have otherwise been accommodated by domestic politics, driving Latin American space programs to seek other international partners. The thesis concludes with recommendations for increasing U.S. engagement with these programs.

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ABSTRACT

This thesis seeks to understand the internal motivations driving some Latin American countries to pursue space programs, how these programs interact at the regional level, and how countries with more developed space capabilities influence these efforts. This thesis also provides insight on the following questions: What obstacles have impeded the development of Latin American space capabilities thus far, and what are the prospects for future regional and international cooperation?

This thesis finds that domestic politics matter most when determining the regional and international orientation of these space programs. Domestically, the desire to develop economically is the fundamental driver. While the era of military rule encouraged geopolitical competition among some of these programs, this faded after the return to democracy. Space now competes poorly with other social and developmental priorities due to a lack of electoral incentives for politicians. International collaboration is restricted by nuclear and missile nonproliferation regimes. U.S. export control regulations limit the scope of potential projects that might have otherwise been accommodated by domestic politics, driving Latin American space programs to seek other international partners. The thesis concludes with recommendations for increasing U.S. engagement with these programs.

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LIST OF ACRONYMS AND ABBREVIATIONS

ABACC	Brazilian-Argentine Agency for the Accounting and Controlling of Nuclear Materials
ABAE	Bolivarian Agency for Space Activities [Venezuela]
ABE	Bolivian Space Agency
ACE	Chilean Space Agency
ACS	Alcântara Cyclone Space [Brazil-Ukraine]
AEB	Brazilian Space Agency
AECA	Arms Export Control Act
AEM	Mexican Space Agency
ALAS	Latin American Alliance of Space Agencies
AMSAT	Radio Amateur Satellite Corporation
APSCO	Asia-Pacific Space Cooperation Office
AR-SAT	Argentine Satellite Solutions Company
ATPDEA	Andean Trade Preferences and Drug Eradication Act
CBERS	China-Brazil Earth Resource Satellite
CAST	Chinese Academy of Space Technology
CCE	Colombian Space Commission
CCL	Commerce Control List
CD	Conference on Disarmament
Celac	Community of Latin American and Caribbean States
CGWIC	China Great Wall Industry Corporation
CIDA-E	Aerospace Research Dissemination Center [Uruguay]
CLA	Alcântara Launch Center [Brazil]
CLBI	Barreira do Inferno Launch Center [Brazil]
CLIRSEN	Center for National Resource Extraction by Remote Sensing [Ecuador]
COBAE	Brazilian Commission of Space Activities [Brazil]
COMAER	Aeronautics Command [Brazil]
CONAE	National Commission of Space Activities [Argentina]
CNAE	See GOCNAE

CNIE	National Commission of Space Research [Argentina]
CNPq	National Council of Technological and Scientific Development [Brazil]
CoC	Code of Conduct for Outer Space Activities
CONEE	National Commission on Outer Space [Mexico]
CONIDA	National Commission of Aerospace Research and Development [Peru]
CTA	Aerospace Technical Center [Brazil]
DAE	Space Activities Division [Brazil]
DCTA	Department of Science and Aerospace Technology [Brazil]
EADS	European Aeronautic and Defense Company (aka Airbus Group)
ESCO	Engineering Services Company [Ecuador]
ESA	European Space Agency
EXA	Ecuadorian Civilian Space Agency
FAA	Argentine Air Force
FAC	Colombian Air Force
FAE	Ecuadorian Air Force
FACh	Chilean Air Force
FAP	Peruvian Air Force
Finep	Financier of Studies and Projects [Brazil]
FTAA	Free Trade Area of the Americas
GEO	Geostationary Orbit
GETEPE	Executive Group for Space Studies and Projects [Brazil]
GDP	Gross Domestic Product
GOCNAE	Organizing Group for the National Commission on Space Activities [Brazil]
GOES	Geostationary Operational Environment Satellite [Unites States]
GSDC	Geostationary Defense and Strategic Communications Satellite [Brazil]
GTO	Geostationary Transfer Orbit
IAE	Institute of Aeronautics and Space [Brazil]
ICJ	International Court of Justice
IEE	Ecuadorian Space Institute

IIAE	Institute of Aeronautics and Space Research [Argentina]
INPE	National Institute of Space Studies [Brazil]
INRAS	Radio Astronomy Institute (part of PUCP) [Peru]
IPD	Institute of Research and Development [Brazil]
ISI	Import Substitution Industrialization
ISS	International Space Station
ITA	Aeronautics Technological Institute [Brazil]
ITAR	International Traffic in Arms Regulations
Itamaraty	Ministry of Foreign Relations [Brazil]
LEO	Low-Earth Orbit
LIT	Integration and Testing Laboratory [Brazil]
MAER	Ministry of Aeronautics [Brazil]
MCTI	Ministry of Science, Technology, and Innovation [Brazil]
MECB	Brazilian Complete Space Mission
MERCOSUR	Common Market of the South
MD	Ministry of Defense [Brazil]
MTCR	Missile Technology Control Regime
MTT	Ministry of Transportation and Telecommunications [Chile]
NASA	National Aeronautics and Space Administration
NEE	Ecuadorian Spaceship
NRL	Naval Research Laboratory [United States]
OAS	Organization of American States
OCED	Organization for Economic Co-operation and Development
OSCAR	Orbiting Satellite Carrying Amateur Radio
PNAE	National Program of Space Activities [Brazil]
PPWT	Treaty on the Prevention of the Placement of Weapons in Outer Space
PUCP	Pontifical Catholic University of Peru
SAC	Scientific Applications Satellite [Argentina]
SCD	Data Collection Satellite [Brazil]
SCT	Communications and Transportation Secretariat [Mexico]
SCUP	Brazilian Sub-secretariat Of Research Unit Coordination [Brazil]

SINDAE	National System for the Development of Space Activities [Brazil]
SIVAM	Amazon Surveillance System [Brazil]
SNaP	Space and Missile Defense Command Nanosatellite Program [United States]
SSA	Space Situational Awareness
SSOT	Earth Observing Satellite System [Chile]
SSR	Remote Sensing Satellite [Brazil]
SSTL	Surrey Satellite Technology Limited [United Kingdom]
UAP	Peruvian Wings University
UN	United Nations
UNAM	National Autonomous University of Mexico
UNASUR	Union of South American Nations
UNSC	UN Security Council
USML	United States Munitions List
VEC	Venezuelan Space Center
VLM	Microsatellite Launch Vehicle [Brazil]
VLS	Satellite Launch Vehicle [Brazil]
VRSS	Venezuelan Remote Sensing Satellite

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I. INTRODUCTION

A. IMPORTANCE

This thesis seeks to understand the internal motivations driving some Latin American countries to pursue space programs, how these programs interact at the regional level, and how countries with more developed space capabilities influence these efforts. In addition to understanding the motivations behind Latin American space programs, this thesis also seeks to shed light on the following questions: What obstacles have impeded the development of Latin American space capabilities thus far, and what are the prospects for future multilateral regional and international cooperation?

While developed nations continue to dominate space technology development, more developing nations are seeking to acquire space capabilities, as evidenced by the rapid recent proliferation of national space programs. From 1950 to 2000, the world went from having no space programs or capabilities to having 48 civilian space agencies, with 37 countries possessing the ability to operate satellites, and nine countries achieving domestic satellite launch capabilities.[1] In 2009, 23 of the top 25 countries with the largest economies as ranked by gross domestic product (GDP) had national space programs.[2] In Central and South America, Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Mexico, Peru, Uruguay, and Venezuela have established official space programs, while French Guyana provides Europe with equatorial launch facilities.

According to estimates made by the Organization for Economic Co-operation and Development (OECD), the investment of roughly $200 billion in space programs worldwide from 1996 to 2005 reaped roughly $500 billion in revenues for the space value chain and an estimated $700 billion in benefits to society (in the form of efficiencies and

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[1] Bryan R. Early, “Exploring the Final Frontier: An Empirical Analysis of Global Civil Space Proliferation,” *International Studies Quarterly* 58, no. 1 (March 1, 2014): 61, doi:10.1111/isqu.12102.

[2] Robert C. Harding, “Space Policy in Latin America: The Final Frontier of Development and Security,” *The Latin Americanist* 53, no. 1 (2009): 178, http://search.proquest.com.libproxy.nps.edu/docview/60038310/4353BA9F542C4DE6PQ/9?accountid=12702.

cost avoidances).[3] It is understandable that developing countries would like to secure a larger share of these direct and indirect benefits for themselves; however, the start-up costs for domestic space capabilities are considerable. These costs include not only the development of space hardware and ground infrastructure, but also the investment in human capital required to support space operations. These costs constrain the development strategies for Latin American countries at the domestic level.

On the regional level, space development in Latin America initially followed a dual civilian-military strategy, similar to developing nations in other regions of the world; however, Latin America has a much different regional and international dynamic. For example, the intense competition that characterizes space development between Asian countries no longer exists in Latin America. Understanding the circumstances unique to Latin America can help account for the differences in development strategies and the slower pace of development.

At the international level, Latin American countries are also eager to reduce their reliance on great powers. There is still a widespread belief among many in Central and South America that their lack of development is due to interference from the developed world, specifically the United States. This belief finds some support in space development. For example, the United States played an active role in blocking the transfer of missile technology to the Brazil during the Cold War.[4] U.S. export restrictions have limited U.S. collaboration on space projects in Latin America, motivating the region to look for partners elsewhere, including China and Russia.[5] But these relations have not always been easy or smooth for Latin American nations. Understanding the international aspirations of Latin America, along with its relationship to the United States and outside powers can also help explain the slower pace of space development.

[3] OECD, *The Space Economy at a Glance 2011* (Paris, France: OECD Publishing, 2011), 28, http://dx.doi.org/10.1787/9789264111790-en.

[4] Wendy Hunter, "The Brazilian Military after the Cold War: In Search of a Mission," *Studies in Comparative International Development* 28, no. 4 (1994): 39, http://link.springer.com/article/10.1007/BF02687126.

[5] Johanna Mendelson Forman, Vincent G. Sabathier, and Ashley Bander, *Toward the Heavens: Latin America's Emerging Space Programs* (Washington, D.C.: Center for Strategic and International Studies, 2009), 8.

B. PROBLEMS AND HYPOTHESIS

Although relatively free from major conflict between states, Latin American countries are continually plagued by internal violence. In response to this internal violence, Latin American militaries have an increasingly institutionalized focus on internal, rather than external, security (e.g., Brazil and Mexico).[6] This thesis hypothesizes that economic development has always been the fundamental motivation of Latin American space programs; however, many countries that experienced military dictatorships during the latter half of the twentieth century also engaged in geopolitical competition. Countries that had active space programs during this period imparted this this geopolitical focus to their programs; however, this focus faded during the widespread transition from authoritarianism to democracy during the 1980s. Although Latin American countries view space as an important avenue of economic development, space projects must compete with internal security and social welfare projects for funding in a democracy.

The transition to democracy also influenced the regional focus of space development. During the period of military dictatorships, Brazil and Argentina engaged in a nuclear weapon and ballistic missile arms race; however, after the end of the Cold War, nuclear competition was replaced with cooperation with the signing of the Foz do Iguaçu Declaration on 12 December 1991, creating the *Agência Brasileiro-Argentina de Contabilidade e Controle de Materiais Nucleares* (Brazilian-Argentine Agency for the Accounting and Control of Nuclear Materials [ABACC]).[7] Other examples of regional cooperation include the Organization of American States (OAS) and the Common Market of the South (MERCOSUR).

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[6] Jorge Zaverucha, "Fragile Democracy and the Militarization of Public Safety in Brazil," *Latin American Perspectives* 27, no. 3 (May 1, 2000): 8, http://www.jstor.org/stable/2634079; Arturo C. Sotomayor, "Militarization in Mexico and Its Implications," in *The State and Security in Mexico: Transformation and Crisis in Regional Perspective*, ed. Brian J Bow and Arturo Santa Cruz (New York: Routledge, 2013), 42.

[7] Arie Marcelo Kacowicz, *Zones of Peace in the Third World: South America and West Africa in Comparative Perspective*, SUNY Series in Global Politics (Albany, NY: State University of New York Press, 1998), 85.

To date, Latin American nations have not formed a multilateral space agency analogous to the European Space Agency (ESA). The natural choice to lead a Latin American space agency is Brazil. As Susan Gratius argues, Brazil, lacking nuclear weapons, "is a soft power committed to civic values such as peace, democracy, and integration or cooperation among states."[8] Yet, such an agency was proposed as early as 1991, but it was opposed by Brazil, a stance it would reverse later.[9] Most recently, in December of 2013, Brazil proposed the formation of the Latin American Alliance of Space Agencies (ALAS).[10] One possible explanation for this reversal is that Brazil's stance is not only tied to its evolving aspirations for "cooperative hegemony" in the region, but its stance is also coupled with progress or setbacks suffered in its international outreach in space.[11] The lack of cooperation among Latin American nations may also contribute the overall slower pace of space development.

International forces strongly influence Latin American space programs. First, these fledgling programs rely heavily on expertise from developed nations, especially the pioneers of space technology. As James Clay Moltz argues, all late-developing space programs share this challenge.[12] In the absence of strong U.S. collaboration, Latin American space programs have reached out to China, India, Russia, and Ukraine. China, in particular, has cooperated on satellite development with Brazil and Venezuela.[13] Thus, this thesis proposes that Latin American space programs face similar challenges and benefits that other late-developing nations experience, and that outreach to traditional U.S. rivals is as much motivated by necessity as by any potential anti-American

[8] Susanne Gratius, *Brazil in the Americas: A Regional Peace Broker?* (Madrid, Spain: Fundación para las Relaciones Internacionales y el Diálogo Exterior, 2007), 24, http://www.plataformademocratica.org/Publicacoes/4656_Cached.pdf.

[9] Harding, "Space Policy in Latin America," 183.

[10] Doug Messier, "Brazil Proposes Latin American Space Alliance at Parabolic Arc," accessed April 4, 2014, http://www.parabolicarc.com/2013/11/17/brazil-proposes-latin-american-space-alliance/.

[11] Gratius, *Brazil in the Americas*, 24.

[12] James Clay Moltz, *Asia's Space Race: National Motivations, Regional Rivalries, and International Risks* (New York, NY: Columbia University Press, 2012), 23.

[13] Yun Zhao, "The 2002 Space Cooperation Protocol between China and Brazil: An Excellent Example of South–South Cooperation," *Space Policy* 21, no. 3 (August 2005): 213–19, doi:10.1016/j.spacepol.2005.05.003; R. Acevedo et al., "Space Activities in the Bolivarian Republic of Venezuela," *Space Policy* 27, no. 3 (August 2011): 174–79, doi:10.1016/j.spacepol.2011.02.003.

sentiment. Additionally, non-U.S. space patrons also have their own interests and limitations, causing some of these efforts in Latin America to encounter problems.

Second, international nuclear and missile nonproliferation regimes have also hindered space development in Latin America. The United States' strict adherence to export control can be traced, in part, to the short-lived arms race between Brazil and Argentina during the period of military rule in both countries. Consequently, Latin American countries must clearly demonstrate their peaceful intentions for dual-use technology to the United States. For example, in response to the lingering U.S. doubts about the military applications of its space program, Brazil joined the Missile Technology Control Regime (MTCR) and created a civilian space agency.[14]

Finally, Latin American progress in space is hindered by failed or strained international collaborations. As an example, the Brazilian Space Agency (AEB) entered into an agreement with the National Aeronautics and Space Administration (NASA) to provide flight hardware for the International Space Station (ISS). The AEB failed to live up to this agreement due to domestic coordination and funding problems.[15] Thus, internal instability limits future international collaborations.

C. LITERATURE REVIEW

Not surprisingly, a vast field of literature exists treating the space policies and ambitions of great powers and developed nations. In contrast, very little has been written about Latin American space programs, which are typically grouped with other space programs in the developing world. Even then, much of what is written about Latin American space programs tends to focus almost exclusively on Brazil, which has the most developed program of Latin America. References to smaller individual Latin American programs occur only sporadically throughout the literature.

[14] Darly Henriques da Silva, "Brazilian Participation in the International Space Station (ISS) Program: Commitment or Bargain Struck?," *Space Policy*, Brazilian Participation in the International Space Station Program, 21, no. 1 (February 2005): 59, doi:10.1016/j.spacepol.2004.11.006; Victor Zaborsky, "The Brazilian Export Control System," *The Nonproliferation Review* 10, no. 2 (2003): 128, doi:10.1080/10736700308436937.

[15] Otavio Durão, "Planning and Strategic Orientations of the Brazilian Space Program," in *Space Strategy in the 21st Century: Theory and Policy*, ed. Eligar Sadeh (New York, NY: Routledge, 2013), 342.

This thesis expands on the work of Robert Newberry and Robert Harding, the only two authors who have examined the motivations of Latin American space programs as a group, to date.[16] Two large issues emerge from their research. First, how should the space ambitions of Latin American countries be interpreted from an international relations perspective? Both authors view space programs from the realist paradigm of international relations, which leads to the second issue: how does one assess the contribution of a space program to national power? Each author attempts to classify Latin American space programs based on capabilities.

Robert Newberry analyzes Latin American space programs from a U.S.-centric point of view, considering the potential threats Latin American space programs pose to U.S. interests in the Western Hemisphere. He acknowledges that the denial of missile technology to the region by the United States drove these countries to seek partners elsewhere. Consequently, he argues that the United States should collaborate more openly with Latin American space programs to counteract the growing influence of China in the region; however, he still classifies programs with strong ties to China as competitors to U.S. interests.[17] He does not discuss the aspirations of each program in a regional or international framework, aside from identifying alignment with the United States or its rivals.

Newberry classifies the capabilities of Latin American space programs based on a three-tiered system. At the top (level 3) he places "countries with a mature space program and an indigenous capability to own or operate space systems…and technical capability to develop spacecraft hardware;" however, these countries do not possess a domestic satellite launch capability, or the ability to fabricate "large-scale" satellite systems.[18] In level 2, Newberry includes "countries that have the research capabilities and intellectual

[16] Robert D. Newberry, "Latin American Countries with Space Programs: Colleagues or Competitors?," *Air and Space Power Journal* 17, no. 3 (Fall 2003): 39–48, http://www.airpower.maxwell.af.mil/airchronicles/apj/apj03/fal03/newberry.html; Harding, "Space Policy in Latin America."

[17] Newberry, "Latin American Countries with Space Programs."

[18] Ibid.

capital needed…to contribute design ideas and some hardware to a space program."[19] Finally, at level 1 are countries "that are willing participants in other space programs and that can contribute either intellectual or financial resources to a collaborative venture with another space-faring country."[20] While these levels make sense for the rough sketches Newberry gives, they are too vague for a detailed comparison between programs. He does not define what constitutes a mature space program, nor the dividing line between large-scale and small-scale satellites. Overall, these categories fail to link the capabilities of a space program to national power.

Newberry's work established the foundation for Robert Harding's follow-up work on Latin American space programs. In his analysis, Harding uses the same classification system as Newberry but adds an international framework. He argues that space capabilities have become an indicator of national power in the international community, a realist point of view. He concludes: "Latin America's states have pursued space-related programs…for the same reasons as their developed world counterparts—to further their national security and development agendas."[21] This blanket comparison masks some important distinctions. First, realist theories assume that states react to the anarchical international environment independent of the domestic politics within the state. For many Latin American states, the opposite is true—internal politics are sometimes more anarchic than the international environment.[22] Second, even during the era of military dictatorship, Latin American states had a strong tradition of participation in regional and international organizations and adherence to norms.[23] Finally, only Brazil and Argentina experienced what could be termed an arms race, at least in the modern era. Other Latin American space programs established peaceful goals from the beginning. Thus, realism

[19] Ibid.

[20] Ibid.

[21] Harding, "Space Policy in Latin America," 184.

[22] Stephanie G. Neuman, "International Relations and the Third World: An Oxymoron?," in *International Relations Theory and the Third World*, ed. Stephanie G. Neuman, 1st ed (New York: St. Martin's Press, 1998), 3.

[23] Arie Marcelo Kacowicz, *The Impact of Norms in International Society: The Latin American Experience, 1881–2001* (Notre Dame, ID: University of Notre Dame Press, 2005), 43.

may not offer a complete or especially useful description of the motivations behind Latin American space programs.

Harding extends his work on Latin America to analyze all space programs in the developing world, modifying Newberry's three-tiered classification system to make a clearer connection to national power. Inverting Newberry's levels, he defines "first tier" developing states as follows:

> The most advanced space actors in the developing world…have achieved the capability to autonomously produce space technology, have developed (or are on the cusp of developing) indigenous launch capability for both orbital and geosynchronous satellite placement, and have national space agencies, and whose space programs evolved from the development (or attempted development) of ballistic missile and nuclear programs.[24]

This level corresponds to Newberry's "level 3" countries. While this definition makes clearer stipulations of capabilities, it does not create a solid foundation for making comparisons between the programs of each country. First, Harding classifies Brazil, China, and India as the only first tier developing states. While China and India may be classified as a developing nations based on GDP, their space capabilities are far ahead of Brazil. Second, the stipulation of nuclear and ballistic missile pursuits is arbitrary. Given the current nonproliferation regimes, developing nations are strongly discouraged from pursuing both nuclear power and ballistic missile programs simultaneously. Thus, this technical path may be closed to future developing nations that meet all the other criteria for first-tier status. Also, not all states that pursue these technologies achieve them, like Brazil. This leads to the third point: classifying Brazil as a first-tier developing space power under this definition is dubious. The stipulation of being "on the cusp" of developing satellite launch capability seems designed to allow Brazil into this group. Brazil does not possess nuclear weapons or ballistic missiles, and its progress on developing indigenous satellite launch capabilities has stalled. Thus, the connection between national power and the classification of a first-tier state is lost due to the large disparities in capabilities among the group.

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[24] Robert C. Harding, *Space Policy in Developing Countries: The Search for Security and Development on the Final Frontier* (New York, NY: Routledge, 2012), 78–79.

Brazil has more in common with what Harding classifies as "second-tier" developing states: "those that produce some of their own technology, have basic launch capacity (typically sounding rockets), have national space agencies, and frequently, out of necessity, collaborate with more advanced states' programs."[25] All other Latin American space programs are classified as "third-tier" developing states (corresponding to Newberry's "level 1"), which "occasionally make contributions in space-related technology, almost always purchase space-related technology from more advanced producers, and almost always collaborate with other more developed space actors."[26]

Harding still maintains that realism provides the best framework for understanding the motivations of developing nations to invest in space programs. While he acknowledges that "liberalism enlightens our understanding of some of the events of the waning years of the Cold War as well as the immediate post-Cold War period," he asserts that "even when states undertake space projects that are presumably cooperative in nature, the true intention is normally to further…political, strategic, and economic goals…and not necessarily to promote the 'good of all mankind.'"[27] While it is undoubtedly true that nations seek mutual benefits from cooperation, it misses the point of cooperation in the liberal international relations paradigm. As Keohane and Nye argue, as countries cooperate they become more interdependent, reducing the chances for military conflict.[28] Countries with large internal problems are motivated to avoid external conflicts.

Harding further discounts the other international relations schools by asserting that "in the near term, the cooperative, conflict-free use of space seems unlikely because national space policies, particularly of the larger, more capable states, have been almost exclusively fashioned according to the tenets of realist competition."[29] This view seems overly deterministic given the near-term incentives that great powers have to cooperate to

[25] Ibid., 79.

[26] Ibid.

[27] Ibid., 20, 28.

[28] Robert O Keohane and Joseph S Nye, *Power and Interdependence* (New York, NY: Longman, 2001), 212.

[29] Harding, *Space Policy in Developing Countries*, 28.

preserve space as a viable commercial domain. Moltz argues that due to the fragility of the space environment—the actions of a single space-faring nation can fill the orbital environment with destructive debris ruining it for all—great space powers have a strong incentive to limit military competition in space.[30]

Cooperation in space is another large issue in the literature on Latin American space programs. Common themes include the lack of U.S. cooperation, the influence of other space actors in the region (Russia, China, and India), and new possibilities for regional cooperation. A report issued by the Center for Strategic and International Studies echoes Newberry's assertion that the United States should reassert its leadership in the region by collaborating with these space programs.[31] The authors argue that engaging in Latin American space projects would provide an avenue for the United States to repair its poor image in the region and gain traction on other security issues in the region (the authors do not specify which security issues).[32] Latin America, in turn, would benefit from greater access to remote sensing technologies critical to monitoring the health of the Amazon River Basin.[33]

In view of the inroads made by China and Russia, the authors Ajey Lele and Ciro Yepes argue that India could also benefit by increasing its technical engagement in the region.[34] As India contemplates privatizing its space launch industry, the authors envision an opportunity for Latin America countries to invest in Indian space launch companies as a way of securing these technologies for themselves.[35] India's motivations for such a collaboration with Latin America, while potentially mutually beneficial, would also aid India's regional competition with Pakistan's, and especially, China's space programs. This is a perfect example of the underlying realist motivations that Harding asserts is

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[30] James Clay Moltz, *The Politics of Space Security: Strategic Restraint and the Pursuit of National Interests*, 2nd ed (Stanford, CA: Stanford University Press, 2011), 5–7.

[31] Forman, Sabathier, and Bander, *Toward the Heavens*, 7.

[32] Ibid., 9.

[33] Ibid., 8.

[34] Ajey Lele and Ciro Arévalo Yepes, "Prospects and Opportunities for Space Collaboration with Latin America: What Can India Contribute and Gain?," *Space Policy* 29, no. 3 (August 2013): 195, doi:10.1016/j.spacepol.2013.06.005.

[35] Ibid.

behind any collaboration in space, but it raises an important question. Why might India prefer collaborating with Latin America, instead of breaking down the barriers preventing collaboration with China?

Lele and Yepes point out that India and Latin America not only share a heritage of colonialism and underdevelopment, but also share “a core set of values—a democracy, market economy, and a strong urge for development by imbibing best practices.”[36] Furthermore, the authors point to the contributions both Latin America and India made to United Nations (UN) outer space treaties and agreements, in particular the UN Declaration in the Exploration and Use of Outer Space for the Benefit and in the Interest of All States, Taking into Particular Account the Needs of Developing Countries.[37] Given these commonalities, the authors are confident that India and Latin American countries can overcome the obstacles of language and geographic distance that have impeded collaboration.[38]

China succeeded in overcoming these barriers to collaborate with Latin America. The China–Brazil Earth Resource Satellite (CBERS) and Venezuela’s *VENESAT-1* are two successful cases of Latin American collaboration with China. Yun Zhao argues that the 2002 protocol established between China and Brazil, emphasizing cooperation on modest scale projects with peaceful purposes, should serve as a model for other developing nations.[39] Likewise, R. Acevedo, of the Bolivarian Agency for Space Activities, highlights the fruits of Chinese collaboration with China on Venezuela’s first communications satellite: 30 doctorate-level space professionals and 60 satellite ground operators trained, two ground stations constructed, and the successful launch and operation of the satellite.[40]

While China’s motivations may be passed off as purely self-interested by the realist school of international relations, Laura Delgado-López argues that, in choosing to

[36] Ibid., 191.

[37] Ibid., 194.

[38] Ibid., 195.

[39] Zhao, “The 2002 Space Cooperation Protocol between China and Brazil,” 217.

[40] Acevedo et al., “Space Activities in the Bolivarian Republic of Venezuela,” 176–77.

cooperate in space, Brazil, China, and Venezuela "are making decisions by weighing costs and benefits from the perspective of their domestic and international policies."[41] She concludes "that failing to consider the interest and constraints of the Latin American countries, and only evaluating the relationship from the perspective of China and the USA, paints an incomplete picture that does not account for the country-by-country variances."[42]

Otavio Durão, however, points out that cooperation can also have a downside. Speaking of the CBERS program, he notes that "Brazilian budgetary problems, along with unpredictable cash flows" required China to step up its contributions to the program, while Brazil suffered from international disapproval by cooperating with China.[43] He predicts these tensions will reduce the scope of Sino-Brazilian cooperation in the future. Since his writing, the launch of the *CBERS-3* satellite failed, resulting in the loss of the satellite.[44] The future of the program beyond *CBERS-4* is uncertain.[45]

Durão also points to the failed U.S.-Brazilian International Space Station (ISS) collaboration as a source of continuing tension. Analyzing this failure, Darly Henriques da Silva argues that the U.S. decision to invite Brazil to participate in the ISS program and Brazil acceptance were based on domestic political concerns, and not technical competence.[46] Brazil had little interest in the ISS itself—its main concern was making its Alcântara Launch Center profitable and sought an agreement that would allow U.S. firms to use the facility.[47] The United States saw an opportunity to improve U.S.-Brazilian

[41] Laura M. Delgado-López, "Sino-Latin American Space Cooperation: A Smart Move," *Space Policy* 28, no. 1 (February 2012): 7, doi:10.1016/j.spacepol.2011.12.009.

[42] Ibid., 13.

[43] Durão, "Planning and Strategic Orientations," 340–41.

[44] Instituto Nacional de Pesquisas Espaciais, "Ciência Sem Fronteiras Terá Bolsas Específicas Para a Área Espacial [Science Without Borders Will Have Specific Scholarships for Space]," July 25, 2013, http://www.inpe.br/noticias/noticia.php?Cod_Noticia=3344.

[45] Instituto Nacional de Pesquisas Espaciais, "Brasil E China Lançam Satélite Em Dezembro E Apostam Na Continuidade Do Programa CBERS [Brazil and China Launch Satellite in December and Bet on the Continuity of the CBERS Program]," accessed October 10, 2014, http://www.cbers.inpe.br/noticia.php?Cod_Noticia=3698.

[46] Silva, "Brazilian Participation in the International Space Station (ISS) Program," 59.

[47] Ibid., 57.

relations in pursuit of establishing the Free Trade Area of the Americas (FTAA), a multilateral free trade agreement for the Western Hemisphere, while shoring up further support for the ISS.[48] Silva argues that both sides share blame for failing to match domestic ambitions with foreign policy.

In summary, the work of Robert Newberry and Robert Harding treats Latin American space programs from the realist point of view; however, their classification systems do not adequately address how space capabilities translate into national power. Furthermore, viewing these programs from a purely realist perspective misses the strong connection of Latin American domestic politics to foreign policy. Domestic politics shape the nature of Latin American cooperation, and matching domestic priorities with international ambitions is key to successful collaborations on space projects.

D. METHODS AND SOURCES

This thesis will examine the history of Latin America's 10 space programs (Argentina, Brazil, Chile, Mexico, Peru, and Venezuela— Bolivia, Colombia, Ecuador, Uruguay are in the appendix) to identify common themes in each, adopting the framework used by Moltz in his study on Asian space programs. His study "employs a multitiered framework beginning with domestic perspectives and national priorities for space, then moving to analyze regionwide interactions and trends, and finally considering implications at the international level."[49] Moltz places these programs within the context of late-developing nations and considers the degree to which technological development objectives, national security pressures, and the desire for international prestige drive each program. Finally, Moltz considers the international relations of these programs from realist, liberal, and constructivist points of view.

Since a comprehensive history of each space mission in each program is beyond the scope of this work, the thesis will also draw on the "Space Technology Ladder" concept developed by Danielle Wood and Annalisa Weigel to assess the technological maturity of each program at key points. This assessment tool offers a 13-tiered rubric

48 Ibid., 58.

49 Moltz, *Asia's Space Race*, 21–22.

starting with the creation of a governmental space office to the indigenous launch of geostationary satellites.[50] The 13 tiers cover four main categories of space development: the establishment of a national space agency, the mastery of low Earth orbit (LEO) satellite technology, the mastery of geostationary Earth orbit (GEO) satellite technology, and the development of launch capability.[51] The lowest level of LEO and GEO capability infers the nation has adequate ground station infrastructure in place. Table 1 (adapted from Table 6 in Wood and Weigel) shows the details of this framework.

Table 1. The Space Technology Ladder[52]

Category	Level	Milestones
Development of Launch Capability	13	GEO launch capability
	12	LEO launch capability
Mastery of GEO Satellite Technology	11	Build locally
	10	Build through mutual international collaboration
	9	Build locally with outside assistance
	8	Procure
Mastery of LEO Satellite Technology	7	Build locally
	6	Build through mutual international collaboration
	5	Build locally with outside assistance
	4	Build with support in partner's facilities
	3	Procure with training services
Formation of National Space Agency	2	Establish national space agency
	1	Establish first national space office

In Table 1, "mutual international collaboration" indicates a partnership where the technical and financial contributions of each party are nearly equal.[53] This differentiates this level from lower levels on the scale that represent a greater dependence on external expertise. While this rubric does not view space programs through a political lens, it does reflect the technological realities faced by late-developing space programs—the

[50] Danielle Wood and Annalisa Weigel, "Charting the Evolution of Satellite Programs in Developing Countries—The Space Technology Ladder," *Space Policy* 28, no. 1 (2012): 17, doi:http://dx.doi.org.libproxy.nps.edu/10.1016/j.spacepol.2011.11.001.

[51] Ibid., 16–17.

[52] Ibid., 17.

[53] Ibid.

technological tree is nearly the reverse of the development path followed by the United States and Russia.

The Space Technology Ladder provides a compelling framework to assess the maturity of a space program; however, it suggests, as Wood and Weigel acknowledge, an evolutionary path that not all countries follow. As experience in Latin America shows, progress in the rubric is not strictly linear. Some countries pursue development of LEO and GEO technologies in parallel, leading to some ambiguity on how to classify these programs. Some programs also develop sounding rockets (sub-orbital) prior to talking LEO launchers. This framework does not capture these efforts. Nor does the framework capture a country's use of data from satellites it does not operate. Also, national space programs differ widely in organization. Some space agencies have near cabinet-level status, while others are managed as sub-organization within a department or ministry. Some are run by the military, while others have civilian leadership. These distinctions are important when determining the span of control exerted by the agency over all space activities in a country. Furthermore a civilian-led space agency is more likely to be accepted by the international community, given the dual-use nature of space technology. To avoid these ambiguities, this study uses the overall framework provided by the ladder to assess the maturity of a space program, but it does not attempt to assign a country a specific level. Even among space programs with nearly equal technical maturity, differences in strategic vision and domestic economy can lead to vastly different outcomes in the future.

Finally, in addition to the journal articles describing the activities of these space programs, this thesis will review the most recent strategic vision or roadmap documents published by each Latin American space program, as well as reports from regional and international organizations, current newspapers, trade journals, and other relevant commentary.

E. THESIS OVERVIEW

Chapter II uses the experience of the Brazilian space program to introduce key themes useful for understanding Latin America as a region, as well as its relationship

with the United States and the rest of the world. Argentina, Brazil's technological peer, could also have been chosen for this purpose; however, the activities of the Argentine space program are not as widely covered in the English scholarly literature, and the Spanish literature is difficult to obtain.

Chapter III reviews the history of the space programs of Argentina, Chile, Mexico, Peru, and Venezuela (Bolivia, Colombia, Ecuador, and Uruguay are covered in the appendix). The chapter then discusses the themes that emerged from these descriptive histories and concludes by assessing their progress on the Space Technology Ladder.

Chapter IV concludes this thesis by examining what the United States can do to increase its engagement with Latin American space programs.

II. THE BRAZILIAN SPACE PROGRAM

The experience of Brazil's space program illustrates several key themes useful not only for understanding other space programs in the region, but Latin America itself. First, the desire to develop economically is the fundamental motivation of Brazil's space program. While it is true that Argentina and Brazil nearly triggered an arms race during the era of military rule, geopolitical competition faded quickly after the return to democracy. Second, domestic politics matter most when determining the regional and international orientation of these space programs. Domestic politics influence everything from economic policy to the specific choice of collaboration partners. Finally, international forces, including international nuclear and missile nonproliferation regimes, also influence these space programs.

This chapter first examines the institutions that currently form the structure of Brazilian space efforts. With this framework in place, this chapter then traces the history of the Brazilian space program in three parts: from its origins in 1957 to formation of the Brazilian Complete Space Mission (MECB) in 1979, from the MECB to the formation of the Brazilian Space Agency (AEB) in 1994, and from the AEB to the present. After discussing the history of the program, this chapter concludes by discussing the strategic orientation of the program both domestically and internationally.

A. THE STRUCTURE OF THE BRAZILIAN SPACE PROGRAM

More so than any other space program in Latin America, the Brazilian space program is characterized by a complex web of civilian and military institutions that have evolved since the late 1950s. Understanding the current structure of the Brazilian space program provides the framework for tracing its trajectory through time. Figure 1 shows an organizational diagram of the key institutions of the Brazilian space program. The *Presidência da República* (President of Brazil) directs the space program primarily through the *Ministério da Defesa* (Ministry of Defense [MD]) and the *Ministério da Ciência, Tecnologia e Inovação* (Ministry of Science, Technology, and Innovation [MCTI]). The *Agência Espacial Brazileira* (Brazilian Space Agency [AEB]) is linked to

the MCTI but coordinates space activities across all other governmental ministries. The *Sistema Nacional de Desenvolvimento das Atividades Espaciais* (National System for the Development of Space Activities [SINDAE]) established in 1996 formalized the relationships between these institutions and their sub-organizations.[54] The next sections discuss the MCTI and MD in more detail.

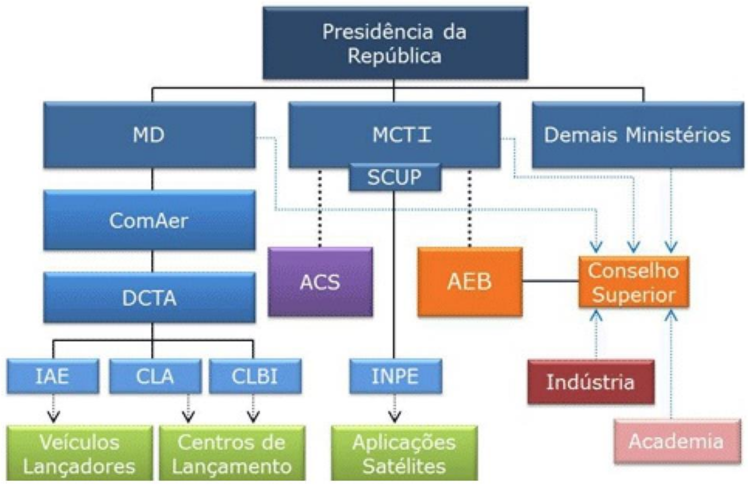

Figure 1. The structure of the Brazilian space program.[55]

1. The Ministry of Science, Technology, and Innovation

The MCTI was founded in 1985 after the transition to democracy. Originally named the Ministry of Science and Technology, the ministry added "Innovation" to its title in 2011.[56] The MCTI combined the activities of the *Financiadora de Estudos e Projetos* (literally translated "Financier of Studies and Projects" [Finep]) and the *Conselho Nacional de Desenvolvimento Científico e Tecnológico* (National Council of Technological and Scientific Development [CNPq]) under one umbrella organization. Historically, these organizations formed the primary means whereby Brazil nurtured the

[54] Agência Espacial Brasileira, *Programa Nacional de Actividades Espacias: 2005–2014 [National Program of Space Activities: 2005–2014]* (Brasília, Brazil: Ministério da Ciência e Tecnologia, 2005), 109.

[55] Agência Espacial Brasileira, "Política Espacial [Space Policy]," accessed September 24, 2014, http://www.aeb.gov.br/programa-espacial/politica-espacial/.

[56] Ministério da Ciência, Tecnologia e Inovação, "Perguntas Frequentes [Frequently Asked Questions]," accessed September 24, 2014, http://www.mcti.gov.br/perguntas-frequentes#titulo3.

development of scientific and technical capacity. The CNPq helped initiate Brazil's first steps to forming a space agency.

Today, the MCTI directly controls the activities of the *Instituto Nacional de Pesquisas Espaciais* (National Institute of Space Studies [INPE]) through the *Subsecretaria de Coordenação das Unidades de Pesquisa* (literally translated Sub-secretariat of Research Unit Coordination, SCUP). INPE is the offspring of the Brazil's first organizing committee for space, the *Grupo de Organização da Comissão Nacional de Atividades Espaciais* (Organizing Group for the National Commission on Space Activities [GOCNAE]) formed in 1961.[57] The primary mission of INPE is the development of technology, often satellites, to support Earth and space research.[58] INPE participated in the successful collaboration with China on the China-Brazil Earth Resources Satellite (CBERS) Program. INPE also runs the *Laboratório de Integração e Testes* (Integration and Testing Laboratory [LIT]), which performs the systems integration and operational testing of satellites and other space instruments or components.[59]

The MCTI is also formally linked to two autonomous organizations, the AEB and Alcântara Cyclone Space (ACS). Formed in 1994, the AEB marked the official transition to a civilian-led space program. Although the president of the AEB reports directly to the President of Brazil, the AEB, like NASA, is not a cabinet-level organization.[60] The *Conselho Superior*, or Board, of the AEB unites representatives from every Brazilian ministry, the Brazilian National Security Council, every military service, Finep, and CNPq to create Brazilian space policy. The AEB expresses this policy in the *Programa Nacional de Atividades Espaciais* (National Program of Space Activities [PNAE]), which

[57] Instituto Nacional de Pesquisas Espaciais, "História [History]," accessed September 24, 2014, http://www.inpe.br/institucional/sobre_inpe/historia.php.

[58] Instituto Nacional de Pesquisas Espaciais, "Missão, Visão E Valores [Mission, Vision, Values]," accessed September 24, 2014, http://www.inpe.br/institucional/sobre_inpe/missao.php.

[59] Durão, "Planning and Strategic Orientations," 336.

[60] Brian Harvey, Henk H. F. Smid, and Théo Pirard, *Emerging Space Powers the New Space Programs of Asia, the Middle East and South-America* (Chichester, United Kingdom: Springer; Published in association with Praxis Publishing, 2010), 316.

lays out Brazil's vision for developing space capabilities.[61] The PNAE has undergone four revisions. The current version the PNAE covers 2012 to 2021. The AEB Board also works to connect government with academia and industry to carry out the activities envisioned in the PNAE.

ACS is officially classified as a binational company linked to the MCTI.[62] The company is a joint venture between Brazil and Ukraine with the goal of using Brazil's *Centro de Lançamento de Alcântara* (Alcântara Launch Center [CLA]) to launch Ukraine's Cyclone-4 launch vehicle. The CLA is located at 2.28° south latitude, placing it in competition with France's *Centre Spatial Guyanais* at 5.3° north latitude.[63]

2. The Ministry of Defense

The Brazilian MD is a relatively new institution, formed on 9 June 1999 during the administration of President Fernando Henrique Cardoso. The new ministry united the three major service commands (army, navy, and air force) under civilian leadership. Previously each service was a separate ministry. The former *Ministério da Aeronáutica* (Ministry of Aeronautics, MAER) was established in 1941 and played a key role in the initiation of and direction of the space program. The *Comando da Aeronáutica* (Aeronautics Command [COMAER]) currently manages all of Brazilian military efforts in space.

COMAER manages the military space effort through the *Departamento de Ciência e Technologia Aeroespacial* (Department of Science and Aerospace Technology [DCTA]). The DCTA has its roots in the *Centro Técnico Aeroespacial* (Aerospace Technical Center [CTA]) established in 1946. Patterned in part after the U.S. Air Force's Army Air Forces Engineering School and research facilities at Wright Field (now Wright-Patterson Air Force Base in Dayton, Ohio), the CTA eventually housed the

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[61] Agência Espacial Brasileira, "Diretorias [Directories]," accessed September 24, 2014, http://www.aeb.gov.br/acesso-a-informacao/institucional/estrutura-organizacional/.

[62] Ministério da Ciência, Tecnologia e Inovação, "Perguntas Frequentes."

[63] Alcântara Cyclone Space, "General Infrastructure," accessed September 24, 2014, http://www.alcantaracyclonespace.com/en/about/general-infrastructure; "Europe's Spaceport," *European Space Agency*, accessed September 24, 2014, http://www.esa.int/Our_Activities/Launchers/Europe_s_Spaceport/Europe_s_Spaceport2.

Institúto Tecnológica de Aeronáutica (Aeronautics Technological Institute [ITA]) and the *Instituto de Pesquisas e Desenvolvimento* (Institute of Research and Development [IPD]).[64] The ITA, established in 1950, is similar to the U.S. Air Force Institute of Technology, but offers both undergraduate and graduate degrees in engineering disciplines to boost the technical expertise of the officer corps. In 1954, the CTA established the IPD to promote aerospace research and outreach to industry.[65]

As the pace of space technology development increased, the Brazilian Air Force created new organizations to promote space within the Air Force. In 1961, the IPD created a *Divisão de Atividades Espaciais* (Space Activities Division [DAE]), which became the *Instituto de Atividades Espaciais* (Institute of Space Activities) in 1969. In 1991, the IPD and the IAE merged to form the current institution, the *Instituto de Aeronáutica e Espaço* (Institute of Aeronautics and Space [IAE]).[66] The IAE played a critical role in the development of Brazilian sounding rockets and currently manages the development of Brazilian satellite launch systems.

In parallel with the activities of the IPD, the CTA also built two launch centers: the *Centro de Lançamento da Barreira do Inferno* (Barreira do Inferno Launch Center [CLBI]) and the *CLA*, mentioned previously. The CLBI, established in 1965, served as the center of activity for Brazilian sounding rocket operations. When it became evident that the site was inadequate to launch larger vehicles, the Air Force established the CLA in 1983.[67]

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[64] Departamento de Ciência e Technologia Aeroespacial, "Uma Idêia Ambiciosa [An Ambitious Idea]," accessed September 25, 2014, http://www.cta.br/historico_ideia.php.

[65] Departamento de Ciência e Technologia Aeroespacial, "Instituto de Pesquisas E Desenvolvimento [Institute of Research and Development]," accessed September 25, 2014, http://www.cta.br/hist_ipd.php; Rodolfo Vilhena de Moraes and Ana Paula Marins Chiaradia, "Instituições e Agências Brasileiras [Brazilian Institutions and Agencies]," in *A Conquista do Espaço do Sputnik à Missão Centenário*, ed. Othon Cabo Winter and Antonio Fernando Bertachini de Almeida Prado (São Paulo, Brazil: Editora Livraria da Física, 2007), 125.

[66] Instituto de Aeronáutica e Espaço, "Histórico [History]," accessed September 25, 2014, http://www.iae.cta.br/site/page/view/pt.historico.html#/7.

[67] Moraes and Chiaradia, "Instituições e Agências Brasileiras [Brazilian Institutions and Agencies]," 133–34.

B. THE HISTORY OF THE BRAZILIAN SPACE PROGRAM

Just as the United States struggled initially to unify the national effort in space, Brazilian space institutions have also evolved to work in concert with one another. This is evident in two key moments. First, the creation of the *Missão Espacial Completa Brasileira* (Brazilian Complete Space Mission [MECB]) in 1979 represented the first attempt to create a unified strategic vision for space development. Second, the establishment of the AEB in 1994 and the subsequent development of the PNAE mark the second, and ongoing, effort to align all Brazilian space activities with a central vision. The next sections use these events to frame the history of the Brazilian space program and place them in the context of the political climate of the time.

1. From a Small Satellite Tracking Station to the MECB

In 1957, Fernando de Mendonça and Júlio Alberto de Morais Coutinho, both Air Force officers attending the ITA, submitted a proposal to the U.S. Naval Research Laboratory (NRL) to build a satellite tracking station to monitor the upcoming U.S. satellite launches during the International Geophysical Year (1957-1958).[68] Funded by the NRL and the working in conjunction with the IPD, the students successfully tracked the Sputnik satellite launched on 4 October 1957, as well as the *Explorer-1* satellite in January of 1958.

These events occurred during the administration of President Juscelino Kubitschek (1956-1961). President Kubitschek took office during turbulent times. In 1954, the nationalistic President Getúlio Vargas committed suicide and the military stood poised to take over the government. Kubitschek prioritized economic development, running on the promise "50 years of development in five."[69] Brazil's rivalry with Argentina, which intensified during the Vargas dictatorship and administration, spurred Brazil to continue its efforts to develop nuclear power. In 1951, President Vargas formed what eventually became CNPq, which adopted nuclear power as a top priority. During the Vargas administration, the United States blocked Brazil's efforts to start a uranium

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[68] Harvey, Smid, and Pirard, *Emerging Space Powers*, 311.

[69] Harding, *Space Policy in Developing Countries*, 111.

enrichment program with the aid of West Germany.[70] Brazil cooperated with the United States through the Atoms for Peace program, resulting in the first nuclear research reactor in the southern hemisphere in 1957.[71] Brazil's nuclear ambitions would shape international opinion on its space program. Kubitschek continued nuclear development in Brazil; however, his term of office ended before space development would begin in earnest, but his presidency set the tone for his successor Jânio Quadros.

Acting on the recommendations on the Inter-American Committee on Space Research, President Jânio Quadros created an exploratory committee to propose the way forward for Brazilian space policy.[72] The efforts of the committee, composed of representatives from CNPq, CTA, IPD, and members of the scientific community, led to the creation of the *Grupo de Organização da Comissão Nacional de Atividades Espaciais* (Organizing Group for the National Commission on Space Activities, GOCNAE, or CNAE for short), which became part of CNPq. Days after officially hosting Yuri Gagarin in Brazil, President Quadros formally created CNAE in July 1961. Although officially a civilian institution, the military essentially ran CNAE. MAER made this evident when it provided the CNAE staff with office space in San José dos Campos, the same city where CTA, ITA, and INP were located.[73] MAER also pursued its own space agenda, creating the DAE in 1961 and forming the *Grupo Executivo e de Trabalhos e Estudos de Projetos Especiais* (shortened in English to Executive Group for Space Studies and Projects [GETEPE]) in 1964.

President Quadros's very short presidency (1961) followed by his successor's, President João Goulart (1961-1965), marked a shift in Brazilian foreign policy that set the military on edge. This new phase, dubbed *política externa independente* (independent foreign policy), reestablished diplomatic relations with the Soviet Union and actively

[70] Togzhan Kassenova, *Brazil's Nuclear Kaleidoscope: An Evolving Identity* (Washington, D.C.: Carnegie Endowment for International Peace, 2014), 18, http://carnegieendowment.org/2014/03/12/brazil-s-nuclear-kaleidoscope-evolving-identity.

[71] Comissão Nacional de Energia Nuclear, "Cronologia Da Energia Nuclear Do Brasil [Chronology of Brazilian Nuclear Energy]," accessed September 26, 2014, http://memoria.cnen.gov.br/memoria/Cronologia.asp?Unidade=Brasil.

[72] Harding, *Space Policy in Developing Countries*, 112.

[73] Harvey, Smid, and Pirard, *Emerging Space Powers*, 312.

sought to cultivate relationships with other developing nations, especially among recently formed countries after decolonization.[74] Goulart's turn towards the left, combined with the turmoil of the Cold War, moved the military to take action. On 31 March 1964, the military successfully launched a *coup d'etat*.[75]

Notwithstanding the political turmoil, the space program pressed forward. On 15 November 1965, CLBI launched its first sounding rocket, representing a successful collaboration between CNAE, MAER, and NASA.[76] The launch supported NASA and other space researchers worldwide studying the sun during the International Quiet Sun Years of 1964–65. CLBI also conducted sounding rocket operations at an alternate launch site at Praia de Cassino (Cassino Beach) in a global effort to study the total solar eclipse on 12 November 1966.[77] While initially dependent on foreign support to build rockets and payloads, Brazil successfully developed its own family of sounding rockets. The increasing capability of these rockets, combined with Brazil's nuclear aspirations and military participation, drew the attention of U.S. nonproliferation efforts.

Notwithstanding Brazil ratifying the Outer Space Treaty and the Treaty of Tlatelolco (both signed in 1967), world powers had reason to doubt Brazil's commitment to nonproliferation. Although the Treaty of Tlatelolco banned nuclear weapons in Latin America and the Caribbean, Brazil and Argentina successfully lobbied to insert language into the treaty allowing for peaceful nuclear detonations.[78] Furthermore, Brazil did not ratify the Treaty of Tlatelolco until 1994. Also in 1967, the military government announced its intentions to master the nuclear fuel cycle.[79] The rivalry between Brazil and Argentina led outside observers to fear a nuclear arms race between the two.[80] To

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74 Alfred P Montero, *Brazil: Reversal of Fortune* (Malden, MA: Polity, 2014), 154; Harold Trinkunas, *Brazil's Rise: Seeking Influence on Global Governance* (Washington, D.C.: The Brookings Institution, April 2014), 9–10.

75 Boris Fausto, *A Concise History of Brazil* (New York, NY: Cambridge University Press, 1999), 277.

76 Harvey, Smid, and Pirard, *Emerging Space Powers*, 313.

77 Ibid., 329.

78 Kassenova, *Brazil's Nuclear Kaleidoscope*, 52.

79 Ibid., 18.

80 Ibid., 22.

add further doubt, Brazil did not sign the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) in 1968. This was an early expression of Brazil's dissatisfaction with the unequal relationship encoded in the treaty between nuclear and non-nuclear states.[81] Brazil would not sign the NPT until 1998.

Brazil's nuclear ambitions would suffer several setbacks the 1970s as it negotiated with the United States for nuclear fuel for its first nuclear power plant, Angra 1. Not only did the United States withdraw its support to provide nuclear fuel, but also it, along with the Soviet Union, interfered with efforts to collaborate with West Germany to export nuclear-fuel-cycle capability to Brazil.[82] For Brazil and other developing nations, this pressure seemed to confirm the fundamental premise behind dependency theory—the idea that developed nations actively prevented the development of other nations. Brazil deeply resented this interference and the desire to minimize external influences in domestic politics drives Brazilian foreign policy to this day.[83]

As the military regime pursued nuclear technology, it also continued to consolidate the Brazilian space effort. In 1969, the GETEPE established the *Instituto de Atividades Espaciais*, which it tasked to develop sounding rockets and orbital launch systems.[84] In 1971, the military combined the activities of MAER and CNAE into a new organization, the *Comissão Brasileira de Atividades Espaciais* (Brazilian Commission of Space Activities [COBAE]).[85] The chief of the *Estado-Maior das Forças Armadas* (Armed Forces General Staff) led the commission, formalizing the military control of the space program. This engendered for Brazil's rocket development the same international suspicion that existed for its nuclear power program. In 1978, COBAE began the work to harmonize all of Brazil's diverse space projects into a single vision. This vision became the MECB.

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81 Ibid., 14.

82 Ibid., 19–20.

83 Ibid., 21.

84 Instituto de Aeronáutica e Espaço, "Histórico."

85 Harvey, Smid, and Pirard, *Emerging Space Powers*, 313.

2. From the MECB to the PNAE

In 1979, the military government approved the MECB, representing Brazil's first long range plan for space. The plan called for INPE to develop four small satellites, two *Satélite de Coleta de Dados* (Data Collection Satellites, SCD) and two *Satélite de Sensoriamento Remoto* (Remote Sensing Satellites, SSR). The SCDs were designed to receive signals from 60 environmental monitoring ground stations scattered through Brazil and communicate this data to a central processing center.[86] The SSRs were envisioned to provide Brazil with the capability of monitoring the Amazon region.[87] The MECB tasked MAER with the development of a launch vehicle, *Veículo Lançador de Satélites* (Satellite Launch Vehicle [VLS]) and the associated infrastructure, including the CLA.[88] As MAER and INPE embarked on the MECB, the *Ministério da Marinha* (Naval Ministry) started a secret program to develop nuclear fuel and reactor for a submarine.[89]

Over the course of the next 10 years, Brazil would spend roughly R$2 trillion (converted to the Brazilian Real, which was not Brazil's currency during this period) pursuing this vision.[90] This ambitious plan reflected the economic optimism of the time. During the period from 1950 to 1980, Brazil experienced high rates of economic growth, often referred to as the "Brazilian Miracle."[91] Unfortunately, Brazil's response to the world oil crisis in 1973 led to debt that would become unmanageable after interest rates

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[86] Durão, "Planning and Strategic Orientations," 338; Orlando Valcir and Hélio Kuga Kuga, "Os Satélites SCD1 e SCD2 da Missão Completa Brasiliera [The Satellites SCD1 and SCD2 of the Complete Brazilian Mission," in *A Conquista do Espaço do Sputnik à Missão Centenário*, ed. Othon Cabo Winter and Antonio Fernando Bertachini de Almeida Prado (São Paulo, Brazil: Editora Livraria da Física, 2007), 174.

[87] Décio Castilho Ceballos, "The Brazilian Space Program: A Selective Strategy for Space Development and Business," *Space Policy* 11, no. 3 (August 1995): 203, doi:10.1016/0265-9646(95)92254-B.

[88] Ibid., 202.

[89] Kassenova, *Brazil's Nuclear Kaleidoscope*, 23.

[90] Roberto de Medeiros Guimarães Filho, "Notas Sobre Planejamento Estratégico Nacional [Notes About National Strategic Planning]," in *A Política Espacial Brasileira*, ed. Rodrigo Rollemberg (Brasília, Brazil: Centro de Documentação e Informação, Edições Câmara, 2010), 266.

[91] Commission on Growth and Development, *The Growth Report: Strategies for Sustained Growth and Inclusive Development* (Washington, D.C.: World Bank, 2008), 20.

rose sharply in 1979. By the 1990s, Brazil's exports fell to roughly half their 1980s volume.[92] The economic downturn helped speed the end of the military regime.

It is uncertain how much Argentina's Cóndor II, an intermediate-range ballistic missile program, motivated Brazil's space ambitions during the 1980s. U.S. intelligence revealed most of what has come to light about the Argentine program.[93] Furthermore, Argentina's loss to Great Britain in the Falklands (Malvinas) War in 1982 signaled the decline of military rule in Argentina. By 1984, civilian rule returned to Argentina, although it pursued the Cóndor II program until 1989, when the high costs of the program and U.S. pressure brought an end to the program.[94] By 1985, Brazil and Argentina, now both under civilian rule, revealed their secret nuclear programs and signed the Joint Declaration on Nuclear Policy.[95] This laid the foundation for the bilateral agreement between the two that established ABACC in 1991, and later the Quadripartite Agreement between Brazil, Argentina, ABACC, and the International Atomic Energy Agency. Both countries also signed the MTCR in 1987.

During the early 1980s, the *Ministério das Relaçoes Exteriores* (Ministry of Foreign Relations, known as Itamaraty) lead an effort to reach out to China. In 1982, Brazil signed an agreement to cooperate in science and technology. After the transition to civilian rule, the MCTI (then the MCT) continued this outreach, leading to an agreement in 1988 to begin the CBERS program. In pursuing the CBERS collaboration, Itamaraty hoped to increase trade with China.[96] The CBERS satellite would serve as a stepping-stone for Brazil to develop the SSR. Both are imaging remote sensing missions; however, the continuing economic problems of Brazil would delay the launch of *CBERS-1* until 1999.

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[92] Ibid., 21.

[93] Carlos Escudé, "An Introduction to Peripheral Realism and Its Implications for the Interstate System: Argentina and the Cóndor II Missile Project," in *International Relations Theory and the Third World*, ed. Stephanie G. Neuman (New York, NY: St. Martin's Press, 1998), 57.

[94] Ibid., 57–58.

[95] Kassenova, *Brazil's Nuclear Kaleidoscope*, 62.

[96] Durão, "Planning and Strategic Orientations," 339.

While the MECB focused on launch vehicles and small LEO satellites, Brazil's telecommunications industry branched out into GEO satellites. The Brazilian government authorized Embratel, a Brazilian telecommunications company, to operate privately procured GEO satellites. *Brasilsat A1* and *Brasilsat A2*, built by the Canadian Spar Aerospace in cooperation with Hughes, launched 1985 and 1986 respectively. To this day, Brazil operates ground stations for its GEO satellites, but continues to procure them from foreign companies.[97]

Brazil returned to civilian rule in 1985. This transition, however, did not happen smoothly. President-elect Tancredo Neves died before taking office. His vice-president, José Sarney, took office in his place. Brazil's efforts to follow International Monetary Fund (IMF) neoliberal guidelines failed to stabilize the Brazilian economy during the 1980s and early 1990s. For a brief period in 1986, after the introduction of the *cruzado* monetary plan, monthly inflation dipped below 10 percent; however, inflation would steadily increase to a high of 80 percent per month by the end of Sarney's term in 1989.[98] The policies of President Fernando Collor de Melo (the first president to be elected by a direct popular vote under Brazil's 1988 Constitution) likewise failed to control hyperinflation. In 1992, the Brazilian Congress impeached President Collor for corruption, elevating Vice-president Itamar Franco to the presidency. During Collor's brief presidency (1990–1992) the space program became more difficult to justify from a strategic view in comparison to the economic crisis.[99] During this period Brazil's defense industry, which had thrived under military rule, collapsed from its peak in 1989 with US$380 million in global sales to US$3 million by the mid-1990s.[100] President Cardoso oversaw the privatization of Brazil's state-owned, military-run aeronautics company, Embraer, as part of his neoliberal economic reforms.[101]

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97 Ibid., 336.

98 Albert Fishlow, *Starting Over: Brazil Since 1985* (Washington, D.C.: Brookings Institution Press, 2011), 35.

99 Rodrigo Rollemberg, "Relatório," in *A Política Espacial Brasileira [Brazilian Space Policy]*, ed. Rodrigo Rollemberg (Brasília, Brazil: Centro de Documentação e Informação, Edições Câmara, 2010), 40.

100 Harding, *Space Policy in Developing Countries*, 114.

101 Montero, *Brazil*, 37–38.

The economic downturn also hobbled progress towards the MECB objectives. Brazil spent approximately R$1 trillion between 1990 and 2000, roughly half of what it spent the previous decade.[102] The MECB did produce it first fruits, however, on 9 February 1993 with the launch of the first Data Collection Satellite, *SCD-1*. INPE contracted the Orbital Sciences Corporation in conjunction with NASA to launch *SCD-1* aboard a Pegasus launch vehicle. While not launched on a Brazilian-made booster, *SCD-1* still represents a key milestone in the Brazilian space program—the first satellite completely designed and built by Brazilians.[103] This year marks the twenty-first year of continuous operations for *SCD-1*.[104] As evidence of the success of the SCD program, the number of ground stations grew from 60 in 1993 to 750 by 2005.[105] Hundreds of these platforms support the *Sistema de Vigilância da Amazônia* (Amazon Surveillance System [SIVAM]), which fuses data received from a network of sensors including ground, air, and space-based assets.[106] SIVAM detects illegal activities such as logging and mining within the region, but also provides intelligence to the Brazilian military on border activities.[107] Although tainted by allegation of corruption, SIAVAM represents a successful U.S.-Brazil collaboration. Brazil chose Raytheon, a U.S. company, to install the radars for the system. SIVAM, however, was also very expensive (US$1.395 billion over 20 years), siphoning funds away from launch vehicle development.[108]

The last year of President Franco's term brought some positive changes to Brazil. In 1994, Franco's minister of finance, Fernando Henrique Cardoso, implemented the Real

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[102] Filho, "Notas Sobre Planejamento Estratégico Nacional [Notes About National Strategic Planning]," 266.

[103] Valcir and Kuga, "Os Satélites SCD1 e SCD2," 156.

[104] Agência Espacial Brasileira, "Primeiro Satélite Brasileiro Completa 21 Anos de Atividade [Brazil's First Satellite Completes 21 Years of Activity]," February 7, 2014, http://www.aeb.gov.br/primeiro-satelite-brasileiro-completa-21-anos-de-atividade/.

[105] Valcir and Kuga, "Os Satélites SCD1 e SCD2," 175.

[106] Ministério da Defesa, "Infraestrutura Tecnológica [Technology Infrastructure]," *Centro Gestor E Operacional Do Sistema de Proteção Da Amazônia Censipam*, accessed October 3, 2014, http://www.sipam.gov.br/assuntos/infraestrutura-tecnologica/texto-de-apresentacao-do-orgao.

[107] Thomaz Guedes Da Costa, *Brazil's SIVAM: As It Monitors the Amazon, Will It Fulfill Its Human Security Promise?* (Washington, D.C.: The Woodrow Wilson International Center, 2001), 48, http://pdf.usaid.gov/pdf_docs/PNADF986.pdf#page=53.

[108] Ibid., 49.

Plan, which effectively halted Brazil's hyperinflation and led to his election to the presidency. In addition to ending hyperinflation woes, Brazil also worked to overcome the military stigma attached to its space and nuclear ambitions. Although President Collor had already terminated the Navy's uranium enrichment program and the Treaty of Tlatelolco and Quadripartite Agreement entered into to effect, Brazil had not yet ratified the NPT.[109] Brazil also replaced CONAE with the AEB in an effort to further consolidate the space program and place it under civilian control.[110] Under its direction, the AEB elaborated the second comprehensive vision for Brazil's space program—the PNAE.

3. From the PNAE and Beyond

Since many of the goals of the MECB remained unrealized by 1994, the first PNAE (released in 1996) retained the same direction for Brazil's space activities. The plan called for development in three specific areas: access to space via domestic launchers, satellites tailored to meet Brazil's development needs, and the further development of national launch centers.[111] In 1996, the Brazilian government formalized the relationships between the various organizations in the space program under SINDAE, ultimately leading to the structure seen in Figure 1. The PNAE, however, did not receive the same budgetary support from the civilian government that the MECB received from the military government. The lack of stable funding destroyed confidence among SINDAE organizations that the federal government was committed to achieving goals laid out in the PNAE.[112] From 1994 to the present day, Brazil's space program enjoyed several brief moments of progress along with many frustrating delays and tragic setbacks. The next sections trace out several activities spanning this period.

[109] Kassenova, *Brazil's Nuclear Kaleidoscope*, 27.

[110] Durão, "Planning and Strategic Orientations," 341.

[111] Maurício Pazini Brandão, "Recursos Humanos Para a Consecução Da Política Espacial Brasileira [Human Resources to Attain Brazilian Space Policy]," in *A Política Espacial Brasileira*, ed. Rodrigo Rollemberg (Brasília, Brazil: Centro de Documentação e Informação, Edições Câmara, 2010), 57.

[112] Durão, "Planning and Strategic Orientations," 337.

a. Brazilian-Chinese Cooperation in the CBERS Program

On 14 October 1999, the first China Brazil Earth Resources Satellite, *CBERS-1*, successfully launched from China. The first two CBERS satellites represent a 30 percent Brazilian, 70 percent Chinese partnership for a total investment of roughly US$300 million.[113] *CBERS-2* launched on 21 October 2003. These satellite provided both countries with the ability to monitor their environments and eliminate dependence on external assets, like Landsat satellites (now currently run by the United States Geological Survey).[114] Based on the success of *CBERS-1* and *2*, Brazil and China renewed their cooperative agreement to produce *CBERS-3* and *4*, this time with Brazil contributing 50 percent of the cost.[115] To help bridge the gap between the operation lifetime of *CBERS-2* and the launch of *CBERS-3*, Brazil and China launched *CBERS-2B* on 19 September 2007. This satellite was a slightly upgraded version of the previous two. *CBERS-3* and *4* included significant upgrades to the imaging cameras, boosting their resolutions to 5 meters.[116] Given the dual military and civilian utility of these images, the United States invoked export restrictions, limiting the availability of components for purchase and delaying the project.[117] *CBERS-3* was launched on 9 December 2013, but failed to reach orbit.[118] *CBERS-4* passed its final design review on 19 September 2014.[119] On 7 December 2014, *CBERS-4* successfully launched from China's Taiyuan space center.[120]

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[113] Zhao, "The 2002 Space Cooperation Protocol between China and Brazil," 215.

[114] Rollemberg, "Relatório," 74; Zhao, "The 2002 Space Cooperation Protocol between China and Brazil," 214.

[115] Rollemberg, "Relatório," 155.

[116] Ibid., 55.

[117] Ibid.

[118] Anthony Boadle, "China-Brazil Satellite Launch Fails, Likely Fell back to Earth," Reuters, December 10, 2013, http://www.reuters.com/article/2013/12/10/us-space-china-brazil-satellite-idUSBRE9B90XK20131210.

[119] Instituto Nacional de Pesquisas Espaciais, "Satélite CBERS-4 Passa Por Revisão Final Na China [CBERS-4 Satellite Passes Through Final Review in China]," accessed October 10, 2014, http://www.cbers.inpe.br/noticia.php?Cod_Noticia=3708.

[120] Stephen Clark, "Chinese-Brazilian Earth Observation Satellite Launched," Spaceflight Now, December 7, 2014, http://spaceflightnow.com/2014/12/07/chinese-brazilian-earth-observation-satellite-launched/.

The future of the CBERS program is in doubt. Although the collaboration is considered a success, China declined to renew the collaboration for *CBERS-5* and *6* in 2009, citing Brazil's difficulty in keeping its commitments.[121] INPE, however, reported the formation a joint working group to explore possibilities for new Earth-observing satellites.[122] The proposals of this group are due by the end of 2014. One thing has become very clear to Brazil: "with a budget five times greater than Brazil's, China has advanced by leap and bounds and surpassed Brazil, emerging as future space power."[123]

b. The VLS Program

Brazil's efforts to develop satellites have enjoyed some success. In 1998, Brazil successfully launched *SCD-2* aboard another Pegasus launch vehicle, continuing the success of the previous satellite. Although this is a success, it highlights an area where Brazil continues to struggle—the development of an orbital launch vehicle.

The MECB initiated the VLS program, and each PNAE highlights its continued importance; however, efforts to develop the VLS have met with little success. Prior to the launch of *SCD-2*, Brazil attempted to launch *SCD-2A* on 2 November 1997 aboard VLS-1 V1, the first flight attempt for the launch system. Had it been successful, it would have represented Brazil's first domestic LEO satellite insertion. During this launch, one of the outer solid rocket boosters failed to ignite. The forces produced by the asymmetric thrust tore the vehicle apart 26 seconds into the flight. The second VLS-1 launch on 11 December 1999 also failed. In this launch, the second stage motor exploded, losing the scientific payload.

The third attempt to launch VLS-1 ended in tragedy on 22 August 2003. Figure 2 shows VLS-1 V3 on the launch pad during the systems integration process. At the time, the mobile launch platform enclosed the rocket, allowing technicians to complete the systems integration with the rocket on the launch pad.

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[121] Rollemberg, "Relatório," 78.

[122] Instituto Nacional de Pesquisas Espaciais, "Brasil E China Lançam Satélite Em Dezembro E Apostam Na Continuidade Do Programa CBERS."

[123] Rollemberg, "Relatório," 78–79 (Translation by author).

Figure 2. The VLS-1 V3 vehicle on the launch pad.[124]

As technicians prepared the vehicle for its 25 August 2003 launch date, one of the four outer solid rocket motors ignited spontaneously, killing 21 technicians and engineers and destroying the launch pad.[125] Figure 3 shows the aftermath of the explosion. Popular media in Brazil forwarded the theory that the United States sabotaged the program in such a way as to cripple further development.[126] An investigation conducted by COMAER, however, ruled out the possibility of sabotage, theorizing that a static electricity discharge from one of the technicians to the ignition circuitry may have been responsible for the accident.[127] The COMAER report also criticized poor management and substandard equipment and parts.[128] Further investigation by the Brazilian Congress

[124] Instituto de Aeronáutica e Espaço, "Fotos [Fotos]," accessed October 8, 2014, http://www.iae.cta.br/site/page/view/pt.fotos.html.

[125] Luna D'Alama, "Tragédia Em Alcântara Faz Dez Anos E Brasil Ainda Sonha Em Lançar Foguete [Ten Years After the Tragedy at Alcântara and Brazil Still Dreams of Launching a Rocket]," Globo.com, August 22, 2013, http://g1.globo.com/ciencia-e-saude/noticia/2013/08/tragedia-em-alcantara-faz-dez-anos-e-brasil-ainda-sonha-em-lancar-foguete.html.

[126] One of many examples of this theory. Carlos Chernji, "Sabotagem Do Tio Sam [Sabotage by Uncle Sam]," Superinteressante, October 2005, http://super.abril.com.br/ciencia/sabotagem-tio-sam-446333.shtml.

[127] D'Alama, "Tragédia Em Alcântara."

[128] Associated Press, "Leadership Blamed in Brazil Space Disaster," Msnbc.com, March 16, 2004, http://www.nbcnews.com/id/4543096/ns/technology_and_science-space/t/leadership-blamed-brazil-space-disaster/.

found that budget constraints contributed to the accident. With restricted and uncertain budgets, the program could not launch frequently, leading to an undertrained technical cadre.[129]

Figure 3. The ruins of the VLS launch tower.[130]

Although Brazil would successfully launch the first VSB-30, a sub-orbital sounding rocket, from Alcântara on 23 October 2004, the VLS-1 V3 accident halted further launch activity. Brazil would not launch another rocket, another VSB-30, until 19 July 2007.

c. *Brazil and the ISS*

Brazil's collaboration with China and progress toward satellite launch capability did not go unnoticed by the United States; however, the decision to collaborate on the ISS hinged on key interests on both sides. Brazil's primary goal was to make CLA a commercially viable launch site for global partners. Since 80 percent of world market for satellites is comprised of U.S. firms, Brazil first had to satisfy the United States of the peaceful nature of its space program.[131] The United States had already rebuffed Brazilian efforts to reach an agreement allowing U.S. firms to use CLA. Furthermore, the MTCR

[129] Rollemberg, "Relatório," 172.

[130] Agência Brasil, "25 de Agosto de 2003 [25 August 2003]," accessed October 10, 2014, http://memoria.ebc.com.br/agenciabrasil/galeria/2003-08-25/25-de-agosto-de-2003?foto=3fde475346ce0#.

[131] Silva, "Brazilian Participation in the International Space Station (ISS) Program," 57.

effectively blocked the transfer of components Brazil required for the VLS program.[132] The United States, on the other hand, was anxious to secure Brazil's support for the FTAA. In addition, the United States needed additional international partners to bolster domestic support for the ISS program, and likely saw an opportunity to check Chinese influence in Brazil's space program.[133] For the United States, the invitation to participate in the ISS represented a non-military avenue for cooperation in space. For Brazil, it represented an offer it could not refuse without jeopardizing other goals.[134]

To overcome U.S. objections to its space program, Brazil passed legislation prohibiting the export of dual-use missile technology and created the AEB as a civilian space agency, both prerequisites to joining the MTCR. Brazil officially joined the MTCR on 27 October 1994. In addition to this, Brazil passed legislation enforcing international patent law, thereby committing to protect intellectual property rights.[135] Brazil also signed the NPT in 1998 to allay fears of Brazil pursuing nuclear weapon technology along with ballistic missiles. Brazil and the United States finalized the ISS agreement in October of 1996 in which Brazil agreed to produce six pieces of flight hardware for the ISS, representing a total investment of US$120 million.[136] In return, Brazil could send experiments to the ISS, as well as one Brazilian astronaut.[137]

Brazil would fail to live up to its ISS commitments for many reasons. First, participating did not directly advance any of the goals set forth in the PNAE. The commitment of US$120 million, even over the course of three years, represented a large fraction of the budget for all Brazilian space activities, this expense coming during the culmination of *CBERS-1* and *2*.[138] This, in turn, accounts for the lack of interest of Brazilian aerospace companies, namely Embraer, to participate. Second, the AEB, in its

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[132] Wyn Q. Bowen, *The Politics of Ballistic Missile Nonproliferation* (New York, NY: Palgrave, 2000), 171.

[133] Silva, "Brazilian Participation in the International Space Station (ISS) Program," 61–62.

[134] Ibid., 58, 61.

[135] Ibid., 59.

[136] Ibid., 61.

[137] Durão, "Planning and Strategic Orientations," 342.

[138] Silva, "Brazilian Participation in the International Space Station (ISS) Program," 61.

infancy, did not have the political clout to lobby for an increase in the space budget to cover the costs of ISS participation. INPE and COMAER still largely ran the organizations that form SINDAE. AEB, located in Brasília, is 1,000 kilometers away from the center of space activities in São José dos Campos (DCTA and INPE) in the state of São Paulo.[139] Third, even if the AEB had more clout, Brazil ran into difficult economic times in the later 1990s and early 2000s. The Mexican Peso crisis in 1994 and the Asian financial crisis in 1998 disrupted Brazilian markets. As a result, Brazil was forced to devalue its currency in 1999. This was followed by the collapse of the Argentine economy and a drought from June 2001 to May 2002 that reduced Brazil's hydroelectric power generation. All of these events pushed Brazil into a recession.[140] By 2002, it was clear Brazil would not fulfill its agreement. Marco Cesar Pontes, the Brazilian astronaut (and Naval Postgraduate School alumni) trained by NASA under this agreement remembers, "INPE removed the project from its organizational diagram. The two-story building, intended to house the technical sector of Brazil's participation in the ISS program, became Chinese 'space.'"[141]

To save some face and keep the program alive, Brazil negotiated with NASA to reduce its commitment to the ISS to US$10 million. As a consequence, NASA cancelled the flight of Marco Pontes to the ISS; however, his flight would occur a different way. In an effort to boost the visibility of Brazil's space program among Brazilians, the AEB decided to plan the *Missão Centenário* (Centenary Mission) to commemorate the 100th year since Santos Dumont's flight around the Eiffel Tower.[142] Russia agreed to train and send Pontes as part of the ISS Expedition 13 crew. On 29 March 2006, he and two Russian crewmembers launched from Baikonur, Kazakhstan. Pontes spent a total of 10 days in space, with eight days at the ISS conducting experiments in microgravity, and

[139] Durão, "Planning and Strategic Orientations," 341.

[140] Montero, *Brazil*, 38.

[141] Marcos Cesar Pontes, "O Brasil na Estação Espacial Internacional - ISS [Brasil in the International Space Station]," in *A Conquista do Espaço do Sputnik à Missão Centenário*, ed. Othon Cabo Winter and Antonio Fernando Bertachini de Almeida Prado (São Paulo, Brazil: Editora Livraria da Física, 2007), 296.

[142] Ibid., 298.

returned with the Russian Expedition 12 crew.[143] The flight, however, did not have the positive public relations effect that the AEB had hoped for. The AEB received a great deal of criticism for the relatively inexpensive cost of US$10 million, paid to the Russians, for the flight.[144]

In the end, neither side achieved all that it hoped. The United States extended the worldwide non-proliferation regime and won concessions from Brazil on patent law but did not receive the promised ISS hardware. Brazil effectively ended further talks on the FTAA.[145] Brazil succeeded in ending the embargo on launch vehicle components and reached an agreement allowing U.S. firms to use the CLA; however, the CLA remains unprofitable at present. Ultimately, the failed cooperation strained Brazil-U.S. cooperation in space.

d. Russian and Ukrainian Cooperation

As further evidence of these strained relations and the struggles the Brazilian launcher program faced after the VLS-1 V3 accident, Brazil reached out to Ukraine and Russia to form joint launch vehicle ventures. In 2003, Brazil and Ukraine signed a treaty creating the Alcântara Cyclone Space Company, paving the way to bring the Ukrainian Cyclone-4 booster to the CLA.[146] The venture is projected to be profitable in roughly 10 to 12 years with a minimum of six launches per year. This will require customers outside of Brazil and Ukraine to ensure profitability since the demand in each country is estimated to be four to five launches per year.[147] If successful, this collaboration will allow Brazil and Ukraine to launch payloads as massive as 5600 kg into LEO and up to 1600 kg into a geostationary transfer orbit (GTO).[148] A GTO is the preliminary orbit

[143] Harvey, Smid, and Pirard, *Emerging Space Powers*, 254–55.

[144] Durão, "Planning and Strategic Orientations," 343.

[145] Fishlow, *Starting Over*, 161–62.

[146] Federative Republic of Brazil and Ukraine, "Treaty Between the Federative Republic of Brazil and Ukraine on Long-Term Cooperation in Utilization of the Cyclone-4 Launch Vehicle at the Alcantara Launch Center," October 21, 2003.

[147] Harvey, Smid, and Pirard, *Emerging Space Powers*, 375.

[148] Alcântara Cyclone Space, "Launch Vehicle," accessed September 24, 2014, http://www.alcantaracyclonespace.com/en/about/launch-vehicle.

required to achieve GEO; hence, the maximum payload to GEO would be less than the figure quoted for GTO. While this would represent a significant capability for both programs, the limited GEO payload is unlikely to attract many customers.[149]

Unfortunately, tensions between Russia and Ukraine have hampered the schedule. In 2004, the Orange Revolution created financial problems in Ukraine, delaying the fabrication of the first booster.[150] In 2014, Russia invaded Ukraine taking Crimea. The unrest continues as of this writing. Originally scheduled for 2006 launch, the first Cyclone-4 vehicle is now scheduled to be delivered to Alcântara in the second half of 2015. According to a project status update posted to the company's website on 16 April 2014, the recent unrest in Ukraine has not impacted the project.[151] There are reasons, however, to doubt this claim. Chief among them is the reliance of Ukraine on Russian subcontractors for components of the Cyclone-4 booster.[152]

Brazilian-Russian cooperation in space dates back to final moments of the Soviet Union. In 1988, Brazil signed an agreement with Russia to cooperate in space for peaceful purposes.[153] Brazil renewed this agreement with Russia in 1997.[154] Russia has focused on assisting Brazil with the development of liquid rocket motors for the VLS program. In 1996, the CTA contracted with the International Center for Advanced Studies of the Moscow Aviation Institute to provide graduate education for Brazilian

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149 Durão, "Planning and Strategic Orientations," 344.

150 Harding, *Space Policy in Developing Countries*, 119.

151 Alcântara Cyclone Space, "Project Status," April 16, 2014, http://www.alcantaracyclonespace.com/en/for-customers/project-status.

152 Yury Zaitsev, "Russia Begins Elbowing Ukraine out from Brazil's Space Program," RIA Novosti, September 17, 2008, http://en.ria.ru/analysis/20080917/116874710.html.

153 Federative Republic of Brazil and Union of Soviet Socialist Republics, "Protocolo Entre O Governo Da República Federativa Do Brasil E O Governo Da União Das Repúblicas Socialistas Soviéticas Sobre a Cooperação No Campo Da Pesquisa Espacial E Da Utilização Do Espaço Para Fins Pacíficos [Protocol Between the Government of the Federative Republic of Brazil and the Government of the Union of Soviet Socialist Republics Over Cooperation in the Field of Space Research and the Peaceful Use of Outer Space]," October 19, 1988.

154 Federative Republic of Brazil and Russian Federation, "Acordo Entre O Governo Da República Federativa Do Brasil E O Governo Da Federação Da Rússia Sobre a Cooperação Na Pesquisa E Nos Usos Do Espaço Exterior Para Fins Pacíficos [Agreement Between the Government of the Federative Republic of Brazil and the Government of Russian Federation Over Research Cooperation and the Peaceful Use of Outer Space]," November 21, 1997.

engineers on liquid rocket propulsion. In the aftermath of the VLS-1 V3 accident, Brazil reached out again to Russia for assistance in modifying the design of the VLS-1 rocket, including testing a new liquid rocket motor design.[155]

Russian investors funded an initial collaboration between AEB and the Russian Federal Space Agency (RKA) called the *Projeto de Sistemas de Lançamentos Espaciais Orion* (Orion Space Launch Systems Project). This project called for a heavy booster capable of launching 14,000 kg into LEO and up to 6,000 kg into GTO.[156] Although this initial program failed financially, a new collaboration began in 2004 called the *Cruzeiro do Sul* (Southern Cross) program, leveraging the Russian RD-191 rocket motor.[157] This ambitious program called for the creation of a family of five launch vehicles, with capabilities ranging from small LEO payloads, to polar orbits, to heavy-lifting GTO boosters.[158] Given the emphasis on launch capability, COMAER was the lead organization for the collaboration.

The initial burst of activity for this project led Yury Zaitsev, an analyst at the Institute of Space Research at the Russian Academy of Sciences, to suggest that Russia was attempting (or perhaps should make the attempt) to muscle Ukraine out of a potentially lucrative market.[159] However, like the many other Brazilian space projects that preceded it, the *Cruzeiro do Sul* has also been plagued by delays. The newest version of the PNAE, covering Brazil's space plans for the period 2012 to 2021, eliminated the largest of the five *Cruzeiro do Sul* vehicles and added a small microsatellite launcher in partnership with Germany.[160] There is no indication today that Brazil is favoring Russia over Ukraine in space cooperation.

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155 Agência Espacial Brasileira, "Europa [Europe]," accessed October 13, 2014, http://www.aeb.gov.br/cooperacao-internacional/acordos/asia/.

156 Harding, *Space Policy in Developing Countries*, 120.

157 Ibid.

158 Paulo Moraes Jr., "An Overview of the Brazilian Launch Vehicle Program Cruzeiro Do Sul" (American Institute of Aeronautics and Astronautics, 2006), doi:10.2514/6.IAC-06-D2.1.08.

159 Zaitsev, "Russia Begins Elbowing Ukraine out from Brazil's Space Program."

160 Agência Espacial Brasileira, *Programa Nacional de Actividades Espacias: 2012–2021* [*National Program of Space Activities: 2012–2021*] (Brasília, Brazil: Ministério da Ciência, Tecnologia, e Inovação, 2012), 20, 28.

C. BRAZIL AND THE SPACE TECHNOLOGY LADDER

As José Raimundo Braga Coelho, president of the AEB writes in the forward of the 2012–2021 PNAE, “This fourth version of the PNAE is decidedly more realistic than previous plans, but it also has eyes fixed on a horizon of dreams.”[161] The plan organizes Brazil’s space activities into two phases. The first phase completes several long-standing projects, like the VLS-1. The second phase builds off these successes to develop strategic capabilities, recognizing the need to boost industry support and to maintain a trained technical cadre.[162]

The launch dates predicted in the plan have already slipped. The *Amazônia-1* satellite, the new name for *SSR-1*, is currently scheduled for a December 2016 launch.[163] The plan also predicted the launch of VLS-1 V4 in 2015, but the two planned test flights prior to this launch have not yet taken place, placing this date into question. Likewise, the *Veículo Lançador de Microsatélites* (Microsatellite Launch Vehicle [VLM]) collaboration with Germany, originally scheduled to launch in 2015, is now scheduled to launch in 2016. As mentioned earlier, the first launch of the Cyclone-4 rocket is now scheduled no sooner than the second half of 2015, when the launch vehicle is now scheduled to be delivered to Alcântara. Finally, the plan predicted the launch of the launch of the first *Satélite Geoestacionário de Defesa e Comunicações Estratégicas* (Geostationary Defense and Strategic Communications Satellite, *SGDC*) in 2014; however, the satellite will not be delivered until 2016.[164]For the purposes of assessing Brazil’s space program using the Space Technology Ladder, projects beyond the time horizon of 2020 are not considered, given the chronic delays experienced by the program. Table 2 matches milestones in the Brazilian space program with the milestones set forth

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[161] Ibid., 5 (Translation by author).

[162] Ibid., 16.

[163] European Space Agency, “The CEOS Database: Mission Summary - Amazonia-1,” accessed October 14, 2014, http://database.eohandbook.com/database/missionsummary.aspx?missionID=602.

[164] Telebras, “Satélite Geoestacionário Vai Garantir a Segurança Das Comunicações Brasileiras [Geostationary Satellite Will Guarantee Security of Brazilian Communications],” accessed October 14, 2014, http://www.telebras.com.br/inst/?p=5208.

in the Space Technology ladder, including projected dates for nearer-term projects (see Table 1 for the explanation of the levels).

Table 2. Brazil and the Space Technology Ladder

Category	Level	Milestones
Development of Launch Capability	13	Beyond 2016: Pending successful Cyclone-4 GTO launch
	12	Projected 2016: Launch of VLM-1
Mastery of GEO Satellite Technology	11	
	10	
	9	
	8	1985: *Brasilsat A1*
Mastery of LEO Satellite Technology	7	1993: *SCD-1*
	6	2013: *CBERS-3* (50% Brazil/50% China)
	5	
	4	1998: *CBERS-1* (30% Brazil/70% China)
	3	
Formation of National Space Agency	2	1971: Formation of COBAE (military) 1994: Formation of AEB (civilian)
	1	1961: Formation of CNAE

Starting at the base of the ladder, Brazil has long had organizations that served the function of national-level space committees and agencies; however, as Brazil's case demonstrates, the existence of these institutions does not necessarily mean the program has a firm foundation.

Brazil's development of LEO satellite technology sheds further insights into the difficulties of developing these technologies. Brazil has long been reliant on satellite data for meteorology and environment monitoring (e.g., Landsat). Given this dependency, Brazil might have procured its own satellites for these purposes; however, as Brazil acknowledges in the 2005–2014 PNAE, countries must develop strategic technologies on their own—Brazil does not want to defer to third parties.[165] Hence, Brazil has focused on

[165] Agência Espacial Brasileira, *Programa Nacional de Actividades Espacias: 2005–2014* [*National Program of Space Activities: 2005–2014*], 7.

developing its own industry and infrastructure and used collaborations that transfer technology to further their goals in this arena.

Collaboration with the United States has been limited by the strict export controls on munitions (which include some satellites and satellite components). Hence, Brazil has reached out to China, Russia, and Ukraine to collaborate. Recently, however, USSOUTHCOM has reached out to Brazil, Chile, and Peru to collaborate on testing the capabilities of a modified CubeSat (a class of small satellites, typically a 10-centimeter cube), *Space and Missile Defense Command Nano-Satellite Program-3* (*SNaP-3*), launched on 5 December 2013.[166] Recent revisions to U.S. export control may permit more extensive collaborations in the future.

GEO satellite technology is different. Here Brazil has exclusively contracted out to international companies to develop and launch these satellites, while Brazilian companies operate them. Historically, Brazil has only purchased GEO satellites for civilian communication. The *SGDC-1* satellite will branch out into specific military capabilities. Brazil is also planning a geosynchronous meteorological satellite, *GEOMET-1*, for launch in 2018.[167] This would eliminate Brazil's reliance on U.S. meteorological assets, like the Geostationary Operational Environmental Satellite (GOES). Brazil and the United States currently share *GOES-12*, which Brazil considers a strategic vulnerability. It is not known at this time how Brazil will construct this satellite, but AEB has announced intentions of using the Cyclone-4 booster for launch.[168]

Finally, while Brazil has enjoyed a successful sounding rocket program, indigenous orbital launch capabilities remain elusive. Brazil's efforts have been the target of U.S. non-proliferation efforts, prompting outreach to U.S. competitors, like Russia. Even with outside assistance, Brazil's program has been hamstrung by faltering budgets,

[166] Ruben Castaneda, "Launch of Nanosatellites a Major Milestone for U.S. SOUTHCOM," Diálogo, accessed November 9, 2014, http://dialogo-americas.com/en_GB/articles/rmisa/features/regional_news/2013/12/10/satellite-launch.

[167] Agência Espacial Brasileira, *Programa Nacional de Actividades Espacias: 2012–2021* [*National Program of Space Activities: 2012–2021*], 27.

[168] Agência Espacial Brasileira, "Consórcio Estuda Construção de Satélite [A Consortium to Study Satellite Construction]," June 29, 2010, http://www.aeb.gov.br/consorcio-estuda-construcao-de-satelite/.

turmoil between Russia and Ukraine, and tragedy. In 2011, the Rouseff administration announced intentions to spend R$2.1 billion over the period 2012 to 2015 in support of the newest PNAE.[169] According the AEB, the program spent roughly R$450 million, giving some hope that Brazil will finally achieve its goals.

D. THE DOMESTIC ORIENTATION OF BRAZIL'S SPACE PROGRAM

The most current PNAE envisions Brazil's space program as a way to stimulate the growth of industry, which in turn secures the strategic and geopolitical value of space to boost Brazil's autonomy and sovereignty.[170] This would indicate realist motivations for pursuing space technology, yet Brazil's commitment to space has wavered from the technical nationalism that characterizes Asian space ambitions to neglect.[171] According to GDP data released by the World Bank on 24 September 2014, Brazil has the seventh largest economy in the world, valued at US$2.2 trillion. China is the second largest, valued at US$9.2 trillion; Russia is just below Brazil as the eighth largest at US$2.1 trillion; and, India is the tenth largest economy at US$1.9 trillion.[172] According to estimates made by the OECD in 2010, China spent US$6.5 billion on space, with Russia spending US$2.7 billion, India US$1.2 billion, and Brazil US$176 million.[173] The reasons why Brazil spends so little on the development of space capabilities demonstrate that domestic politics have the strongest influence on the orientation of the space program.

Part of the difficultly of funding space comes from its connection to the military. Like the military, space simply does not compete well with other social spending priorities in Brazil. With rare notable exceptions, Latin America has transitioned from a

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169 Paola Carriel, "Brasil Reforça Programa Espacial [Brazil Reinforces Space Program]," *Gazeta Do Povo*, October 16, 2011, http://www.gazetadopovo.com.br/vidaecidadania/conteudo.phtml?id=1180928&tit=Brasil-reforca-programa-espacial.

170 Agência Espacial Brasileira, *Programa Nacional de Actividades Espacias: 2012–2021* [*National Program of Space Activities: 2012–2021*], 3.

171 Moltz, *Asia's Space Race*, 22.

172 World Bank, "GDP Ranking," September 24, 2014, http://data.worldbank.org/data-catalog/GDP-ranking-table.

173 OECD, *The Space Economy at a Glance 2011*, 25.

zone of negative peace (the absence of intrastate war) to a zone of stable peace (peace is accepted as a norm).[174] The collapse of the Argentine military after the Falklands/Malvinas War coupled with the end of the Cold War made it difficult for the Brazilian military to justify increased spending. José Viegas Filho, a former Minister of Defense, summed it up succinctly: "Brazil has no enemies. There is not one country in the world that hates us or is prejudiced against us."[175]

This "crisis of identity" sent the military looking for internal missions versus trying to justify its existence against a non-existent external threat.[176] The basis for this focus comes from Article 142 of Brazil's constitution that directs the military to ensure law and order.[177] The Brazilian War College defines internal security as "all the processes by which the state protects itself against antagonisms and pressures of any origin, form, or nature that occur within it."[178] As a result of this broad definition, the number of military officers, active and reserve, has grown across government public safety organizations.[179] The military directs its inward focus to Brazil's "'Green' Amazon (land and river areas within the Amazon Basin) and 'Blue' Amazon (coastal areas of Brazil where major hydro-carbon and other resources are located)."[180] Without a specific threat to defend against, Brazil's military structure must be capable of adapting and massing quickly to threats as they present themselves.[181]

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174 Kacowicz, *Zones of Peace in the Third World*, 122–23.

175 Thomas Bruneau and Scott Tollefson, "Civil–Military Relations in Brazil: A Reassessment," *Journal of Politics in Latin America* 6, no. 2 (2014): 120, http://journals.sub.uni-hamburg.de/giga/jpla/article/view/764.

176 Hunter, "The Brazilian Military after the Cold War," 44.

177 Zaverucha, "Fragile Democracy and the Militarization of Public Safety in Brazil," 9–10.

178 Ibid., 13.

179 Ibid., 11.

180 Max G. Manwaring and Andrew Fishman, "Brazil's Security Strategy and Defense Doctrine" (Army War College, 2009), http://www.strategicstudiesinstitute.army.mil/pubs/display.cfm?pubID=1049.

181 Alcides Costa Vaz, "Brazilian Perspectives on the Changing Global Order and Security Challenges," in *Enhancing the Brazil-EU Strategic Partnership: From the Bilateral and Regional to the Global*, ed. Michael Emerson and Renato Flôres (Brussels, Belgium: Centre for European Policy Studies, 2013), 188.

This presents a puzzle. Providing security for Brazil's vast territory strongly indicates the need for increased spending on space assets. Indeed, Brazil's *National Strategy of Defense* published in 2008, identifies space along with nuclear and cyberspace technologies requiring further investments.[182] Based on 2013 data, Brazil spends more on defense than all other Latin America countries combined (1.29 percent of GPD); however, 73 percent of defense spending funds "wages, salaries, pensions and social security payments," leaving very little to invest in these strategic areas.[183] The money not taken by personnel costs must be spread over many competing projects. Funding for launch vehicle development must compete for funding for SIVAM, for example. This trend of reduced military spending began soon after the transition to democracy.

The reduction of military spending was not exclusively motived by a desire to punish the military for human rights abuses during military rule. After the transition to democracy in 1985, many observers questioned the ability of the new civilian government to reign in military influence in the government, especially in the budget process.[184] These fears proved to be unfounded. In 1988, Brazil's new constitution solidified congressional control over the budget process, creating democratic competition for resources. During military rule, the government concentrated the defense industry in the state of São Paulo.[185] Brazil's launch sites (operated by the military) are too remote and employ too few people to be politically useful. In fact, the CLA has been a political liability for local politicians since the land for the site was expropriated from the poor descendants of a former maroon colony for runaway slaves (*quilombo*).[186] Thus, in contrast to the United States, where legislators fight to secure military spending in their

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[182] Nelson A. Jobim and Roberto Mangabeira Unger, "National Strategy of Defense" (Brasília, Brazil; 2008), 32–34.

[183] Bruneau and Tollefson, "Civil–Military Relations in Brazil," 131.

[184] Wendy Hunter, *Eroding Military Influence in Brazil: Politicians Against Soldiers* (Chapel Hill, NC: University of North Carolina Press, 1997), 96.

[185] Ibid., 98.

[186] Steve Kingstone, "Brazil Spaceport Threat to Villages," BBC, November 9, 2004, http://news.bbc.co.uk/2/hi/science/nature/3985229.stm.

states and districts, only a few Brazilian politicians have an incentive to fund the military to secure votes.

The lack of electoral incentives to fund the military lead to what David Pion-Berlin and Harold Trinkunas describe as "attention deficits" with respect to defense policy—politicians choose not to invest the time necessary to understand the requirements of the armed forces.[187] Thus, funding the military diverts funds from politically expedient social programs, weakening the military's ability to persuade legislators for funds.[188]

Not surprisingly then, the military side of space (launch vehicle development and launch site operations) has made much slower progress than the civilian side of space (satellite applications). Yet, as discussed previously, civilian cooperation with China and United States has also been underfunded. Due to the historically close ties with the military, satellite development is also tied to the defense industry in São Paulo. Thus, civilian space policy in Brazil suffers from the same lack of incentives as military space policy.

Space investments, in general, have two further complications. First, the defense sector had a developed industrial base, but the transition to democracy shrunk its capacity substantially. Because of the erratic funding of the space program, few companies are willing to participate. Those that do participate are looking for ways to court foreign customers to bolster low domestic demand.[189] Thus, the industrial support for the space industry continues to lag. Second, industry and government alike have a shortage of qualified personnel. Brazil is trying to boost the number of qualified professionals by reducing the amount of time required to graduate, increasing the number of graduate schools in space disciplines, and retaining graduates with competitive salaries.[190]

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[187] David Pion-Berlin and Harold Trinkunas, "Attention Deficits: Why Politicians Ignore Defense Policy in Latin America," *Latin American Research Review* 42, no. 3 (January 1, 2007): 76, 78–79, http://www.jstor.org/stable/4499390.

[188] Hunter, *Eroding Military Influence in Brazil*, 98, 105.

[189] Brandão, "Recursos Humanos Para a Consecução Da Política Espacial Brasileira [Human Resources to Attain Brazilian Space Policy]," 58.

[190] Ibid., 62–63.

In 2011, Brazil launched *Ciência sem Fronteiras* (Science without Borders), an ambitious effort to boost the number of qualified personnel across a wide variety of technical disciplines. The program will fund up to 101,000 scholarships (75,000 federally funded, 26,000 privately funded) at the baccalaureate, master's, and doctorate level over the course of four years.[191] According to data released in September 2014, the program has awarded 71,478 federally-funded scholarships, on track to meet program goals.[192] AEB received a quota of 300 scholarships: 150 for Brazilians to study abroad and 150 for foreign students to study in Brazil.[193]

Although Brazil is aggressively addressing the lack of technical expertise, recent public protests in Brazil further reinforce the politician's incentives to continue neglecting space development. Triggered by an increase in the price of bus fares in São Paulo and overall discontent with the expenditures for the 2014 FIFA World Cup, the protests of 2013 quickly spread to encompass a wide range of grievances. *Datafolha*, a Brazilian polling institute, reported that the top eight grievances were health care, education, corruption, need for change, safety, politicians, quality transport, and transport cost.[194] While bus fares may have sparked the protests, Brazilians are angrier about the quality of their democracy. A Pew research report confirms this widespread dissatisfaction.[195] Given this discontent, funding for the military and space will continue to compete for funding with pressing social issues.

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[191] Ciência sem Fronteiras, "Metas [Goals]," January 22, 2013, http://www.cienciasemfronteiras.gov.br/web/csf/metas.

[192] Ciência sem Fronteiras, "Painel de Controle Do Programa Ciência Sem Fronteiras [Control Panel of the Science without Borders Program]," September 2014, http://www.cienciasemfronteiras.gov.br/web/csf/painel-de-controle.

[193] Agência Espacial Brasileira, "Ação CsF Espacial: Cooperação Internacional Para O Programa Espacial Brasileiro [Science without Borders Space Action: International Cooperation for the Brazilian Space Program]," accessed October 17, 2014, http://csf.aeb.gov.br/; Instituto Nacional de Pesquisas Espaciais, "Ciência Sem Fronteiras Terá Bolsas Específicas Para a Área Espacial [Science Without Borders Will Have Specific Scholarships for Space]."

[194] Ricardo Sennes, *Will Brazil Get What It Expects From the World Cup?* (Washington, D.C.: Atlantic Council, 2014), 6.

[195] Pew Research Center, *Brazilian Discontent Ahead of World Cup* (Washington, D.C.: Pew Research Center, 2014), 8.

E. THE INTERNATIONAL ORIENTATION OF BRAZIL'S SPACE PROGRAM

Large territory, rich natural resources, and a large economy motivate Brazilians to seek a more prominent role in global leadership.[196] Brazil's global aspirations include a permanent seat on the UN Security Council (UNSC) and to have a Brazilian as the Director General of the World Trade Organization and President of the International Development Bank.[197] Brazil, however, still lacks the military and economic clout required to compete for influence among great powers. Even on a regional scale, Sean Burges describes Brazil as leading "without sticks or carrots."[198] Consequently, Brazil attempts to project its influence into the world via "soft power."[199]

Economic development is a key stumbling block to Brazil's global and regional ambitions. Understandably then, economic development motivates Brazil's foreign policy.[200] Economic policy, however, is also rooted in domestic political ideology. Thus, the waxing and waning of Brazil's economic fortunes has resulted in a fluid foreign policy. This is evident in the regional and international orientation of Brazil's space program, which has spanned non-democratic regimes and democratic, as well as center-right and far-left presidencies.

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[196] Peter Hakim, "Two Ways to Go Global," *Foreign Affairs* 81, no. 1 (2002): 157, http://www.jstor.org/stable/20033009.

[197] Andrés Malamud, "A Leader without Followers? The Growing Divergence between the Regional and Global Performance of Brazilian Foreign Policy," *Latin American Politics and Society* 53, no. 3 (2011): 19, http://onlinelibrary.wiley.com/doi/10.1111/j.1548-2456.2011.00123.x/abstract.

[198] Sean W. Burges, "Without Sticks or Carrots: Brazilian Leadership in South America During the Cardoso Era, 1992–2003*," *Bulletin of Latin American Research* 25, no. 1 (January 2006): 23, doi:10.1111/j.0261-3050.2006.00151.x.

[199] Susanne Gratius and Miriam Gomes Saraiva, "Continental Regionalism: Brazil's Prominent Role in the Americas," in *Enhancing the Brazil-EU Strategic Partnership: From the Bilateral and Regional to the Global*, ed. Michael Emerson and Renato Flôres (Brussels, Belgium: Centre for European Policy Studies, 2013), 225.

[200] Russell Crandall, "Brazil: Ally of Foe?," in *The United States and Latin America after the Cold War* (New York, NY: Cambridge University Press, 2008), 146.

During the military regime, the military regime isolated itself internationally to insulate itself from criticisms about human rights violations.[201] The regime also isolated itself economically by implementing Import Substitution Industrialization (ISI) policy, sheltering domestic industry from foreign competition. The policy was successful in boosting Brazilian exports from five percent of GDP in the 1950s to 12 percent by the end of the military regime in the 1980s.[202] Economic success fueled Brazil's competition with Argentina in nuclear and space development; however, although Brazil enjoyed success in selling military arms, Russell and Britta Campbell note that Brazil "spent relatively little on its own military."[203]

In the wake of the oil crisis of 1973 and the ensuing debt crisis in 1979, the military government saw its ISI policy failing and began forging new economic ties.[204] Brazil used technical cooperation in space as an avenue to open better relations with China, leading to the CBERS program after the transition to military rule. As mentioned earlier, the idea for this outreach came from Itamaraty, not the military. Nor was the move motivated by ideological affinities to Chinese socialism.[205] More attractive was the Chinese "no strings attached" policy to lending that did not stipulate conditions on democracy and humans rights. Chinese policy meshes well with the Latin American norms of non-intervention and sovereignty.

After the transition to democracy and as the military was forced to compete for resources, the geopolitical orientation of space activities in Brazil faded, leaving only the developmental objectives that had always been present. Unfortunately, the same attention deficits that hounded defense policy in the new civilian government limited the funding

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201 Arturo C. Sotomayor Velázquez, "Different Paths and Divergent Policies in the UN Security System: Brazil and Mexico in Comparative Perspective," *International Peacekeeping* 16, no. 3 (June 2009): 367, doi:10.1080/13533310903036418.

202 Commission on Growth and Development, *The Growth Report*, 21.

203 Crandall, "Brazil: Ally of Foe?," 158.

204 Commission on Growth and Development, *The Growth Report*, 21.

205 Monica Hirst, "A South-South Perspective," in *China's Expansion into the Western Hemisphere: Implications for Latin America and the United States*, ed. Riordan Roett and Guadalupe Paz (Washington, D.C.: Brookings Institution Press, 2008), 97.

provided to the CBERS program, preventing Brazil from gaining all it could from the collaboration.

Brazil's relationship with the United States is more complicated. Overall, Brazil and the United States enjoy good relations (the revelations of Edward Snowden notwithstanding); however, Brazil's emphasis on regional multilateralism and nonintervention and the U.S. emphasis on free markets restrict the potential areas for cooperation. This is evident in the failure of the Brazil-U.S. ISS collaboration. The United States clearly miscalculated Brazil's support for the FTAA and the ability of Brazilian industry to support the program. Brazil overestimated the U.S. demand for its CLA facilities and underestimated the ill will it would generate with NASA by backing out of its commitments.

The economic downturn of 1998, coupled with the persistent inequality and government corruption of Latin America, created an opening for left-wing political parties to come to power—the so-called "Pink Tide" or New Left.[206] Although the United States was quick to support an IMF rescue package for Brazil, the effort failed to stabilize Brazil's currency.[207] Although President Cardoso was credited with halting Brazil's hyperinflation woes, the crisis damaged the public confidence in his neoliberal reforms, albeit limited, and led to the election of President Luis Inácio Lula da Silva (affectionately known as Lula in Brazil), leader of the Marxist *Partido dos Trabalhadores* (Worker's Party). With Lula's election, the opportunity to improve Brazil-U.S. cooperation in space shrank even further. With Lula's election, outreach to China and Russia at the expense of U.S. relations could be justified at an ideological level. Any hope of further ISS cooperation after Marco Pontes's flight became more distant.

The Lula administration also intensified efforts to increase regional integration. As Susan Gratius and Miriam Saraiva describe, what began with the thawing of relations between Argentina and Brazil in 1985 and the formation of MERCOSUR in 1991 led to the formation of the Union of South American Nations (UNASUR) in 2008 and the

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[206] Peter H. Smith, *Democracy in Latin America: Political Change in Comparative Perspective*, 2nd ed (New York, NY: Oxford University Press, 2012), 198.

[207] Crandall, "Brazil: Ally of Foe?," 152.

Community of Latin American and Caribbean States (Celac) in 2011.[208] MERCOSUR, UNASUR, and Celac provide alternative forums to the OAS, which is the forum the United States participates in. "Soft-balancing" U.S. influence in Latin America became an explicit goal of Brazilian foreign policy during the administration of Lula and his successor President Dilma Rouseff.[209] President Rouseff, however, distanced herself from Lula's outreach to Iran and Venezuela.[210]

While the political maneuverings of these alliances resemble great power politics, two points should be kept in mind. First, the greatest threat to each of these regimes is another economic crisis, not an external military power. Each economic downturn tends to create a crisis of confidence in the electorate for the current policies, increasing the chances of regime change. Second, these organizations are born out the Pink Tide and represent an attempt to minimize the influence of policies thought to have caused the previous economic crisis.[211] Consequently, these organizations often espouse anti-American sentiments, but this is a byproduct of balancing against a domestic threat.[212] Although Steven David uses the framework of realism to describe the alignment of developing nations, Stephanie Neuman is correct to point out that many of the underlying assumptions of realism do not apply to these nations.[213]

Brazil is also active in discussions on international space policy in the UN. Brazil participates in the Conference on Disarmament (CD), the multinational forum established by the UN to discuss issues of nuclear disarmament. The agenda of the CD also includes discussion on the proposed Prevention of an Arms Race in Outer Space (PAROS) treaty.[214] Over the past decade, the CD has debated two main proposals seeking pave the

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[208] Gratius and Saraiva, "Continental Regionalism," 231.

[209] Ibid., 230.

[210] Montero, *Brazil*, 158.

[211] Smith, *Democracy in Latin America*, 198–99.

[212] Steven R. David, "Explaining Third World Alignment," *World Politics* 43, no. 02 (January 1991): 238, doi:10.2307/2010472.

[213] Neuman, "International Relations and the Third World: An Oxymoron?," 3.

[214] Nuclear Threat Initiative, "Conference on Disarmament (CD)," accessed December 12, 2014, http://www.nti.org/treaties-and-regimes/conference-on-disarmament/.

way to a more comprehensive PAROS treaty. In 2008, China and Russia released a draft of the "Treaty on the Prevention of the Placement of Weapons in Outer Space" (PPWT). This treaty sought to ban from space "any device placed in outer space, based on any physical principle, specially produced or converted to eliminate, damage or disrupt normal functions of objects in outer space."[215] The European Union proposed a non-binding Code of Conduct (CoC) for Outer Space Activities that seeks to establish international norms for the peaceful and sustainable use of outer space.[216] Brazil favors the PPWT over the CoC. According to Brazil, "Transparency and confidence-building measures [separate from CoC]…can foster mutual understanding, political dialogue and cooperation among States. Yet we also note that they cannot be a substitute for legally binding norms."[217] The United States opposes the PAROS

With Brazil's emphasis on improving regional relationships, it comes as no surprise that Brazil has revived the idea (one that it once opposed) of a joint Latin American space agency. In October of 2013, Brazil proposed the formation of Aliança Latino-Americana de Agências Espacias (Alliance of Latin-American Space Agencies [ALAS]) at a conference attended by representatives from Argentina, Bolivia, Chile, Costa Rica, Ecuador, México, Paraguay, and Peru participated in the conference.[218] The initial activities of this proposed alliance would focus on two areas: creating collaboration among Latin American universities on small satellite programs and establishing a central digital distribution hub for satellite data. The modest goals of this alliance focus on key developmental needs for fledgling space programs. The timing of this effort, however, comes as unrest and disinterest, respectively, threaten its collaborations with Ukraine and China.

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[215] James Clay Moltz, *Crowded Orbits: Conflict and Cooperation in Space* (New York, NY: Columbia University Press, 2014), 159.

[216] Ibid., 161.

[217] Brazil, "Statement by the Brazilian Delegation on the Thematic Debate on Outer Space (disarmament aspects): First Committee of the 68th General Assembly," October 25, 2013, http://www.un.org/disarmament/special/meetings/firstcommittee/68/pdfs/TD_25-Oct_OS_Brazil.pdf..

[218] Agência Espacial Brasileira, "AEB Propõe Uma Aliança Latino-Americana de Agências Espaciais [AEB Proposes a Latin America Alliance of Space Agencies]," October 6, 2013, http://www.aeb.gov.br/aeb-propoe-uma-alianca-latino-americana-de-agencias-espaciais/.

F. CONCLUSION

The Brazilian space program introduces many themes that help understand Latin America as a region. First, the desire to develop economically is the fundamental driver of Brazil's space program. The era of military rule added a geopolitical element to the program, but this faded after the return to democracy. Since the return to democracy, space now competes poorly with other social and developmental priorities due to a lack of electoral incentives for Brazilian politicians.

Second, domestic politics matter most when determining the regional and international orientation of these space programs. Economic development drives foreign policy in Latin America. Economic failure discredits the development strategies employed by the leaders in power, often ushering in regime change. Economic crises sped the end of military rule in Latin America and assisted the rise of the New Left. Thus, foreign policy remains fluid as the ideology of the government shifts. The emphasis on regional and international cooperation in space is influenced by the development strategy chosen, which is heavily influenced by ideology, and partners are often selected to meet further specific domestic goals, which may be unrelated to space development. Shifting economic fortunes and political stability can also strain and break international collaborations.

Third, international forces also influence these programs. International collaboration is restricted by nuclear and missile nonproliferation regimes, which rankle Latin American sensitivities to the norm of sovereignty.[219] U.S. export control regulations limit the scope of potential projects that might have otherwise been accommodated by domestic politics, driving Latin American space programs to seek other partners, including nations hostile to U.S. interests. Furthermore, the U.S. played a prominent role in establishing the NPT and the MTCR. Consequently, when they are invoked the United States is blamed for intervention. Nevertheless, these fledgling space programs greatly benefit from collaborations with more advanced nations.

[219] Kacowicz, *The Impact of Norms*, 59.

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III. OTHER LATIN AMERICAN SPACE PROGRAMS

The experience of the Brazilian space program introduces themes relevant to the other programs in Latin America. First, economic development has always formed the foundation of each program, and democracy reinforces this focus, erasing any geopolitical imprint a military regime may have imparted. Second, domestic politics are key to understanding the regional and international orientation of each program. The prevalence of military rule in the region highlights the importance of considering the influence of civil-military relationships as part of domestic politics. Like in Brazil, the transition to democracy sent many Latin American militaries scrambling to find new missions and forced them to compete against pressing social issues for funding, directly impacting military budgets for space. Even civilian efforts in space are impeded by a lack of political incentives. Economic boom and bust can also alter domestic politics, which, in turn, can change the orientation of the space program. Finally, international influences can both help and hinder progress in space development. Latin American space programs prefer international collaborations that result in the transfer of technology and the training of human resources. Domestic political ideology can also favor collaboration with some nations and strain relationships with others.

This chapter begins by presenting brief descriptive histories of the space programs of Argentina, Venezuela, Mexico, Peru, and Chile. The chapter then discusses the recurring themes that emerge from these programs in the context of the broader themes introduced in chapter two. The chapter concludes by summarizing the progress of each program on the Space Technology Ladder. The space programs of Bolivia, Colombia, Ecuador, and Uruguay are classified as minor space programs due to the limited scope of the activities of their space agencies. The descriptive histories of these programs are given in the appendix; however, they are discussed as appropriate.

A. ARGENTINA

Argentina's strategic vision, similar to Brazil's concept of *grandeza*, coupled with military rule gave rise to geopolitical competition in space in the 1960s and 1970s.[220] The rivalry with Brazil placed Argentina's technological development in space on a similar trajectory. Like Brazil, Argentina also participated in grass-roots space societies after the end of World War II. Teofilo Tabanera, the founder of the *Sociedad Argentina Interplanetaria* (Argentine Interplanetary Society), led the effort to lobby for the creation of a civilian space agency in Argentina. On 28 January 1960, Argentina founded the *Comisión Nacional de Investigaciones Espaciales* (National Commission of Space Research [CNIE]); however, the decree placed the CNIE under the *Fuerza Aérea Argentina* (Argentine Air Force [FAA]).[221] Like the Brazilian Air Force, the FAA also had a technical institute that conducted space research: the *Instituto de Investigaciones Aeronáuticas y Espaciales* (Institute of Aeronautics and Space Research [IIAE]).

Also like Brazil, much of Argentina's early work in space dealt with sounding rockets. Argentina holds the distinction of launching the first sounding rocket designed and built entirely in Latin America.[222] On 23 December 1969, Argentina became the fourth country in the world to launch a monkey into space. Juan, a capuchin monkey native to Argentina's Misiones province, rode to an altitude of 82 kilometers (there is some uncertainty in sources about the exact altitude) and was safely recovered.[223] In 1970, Argentina succeeded in launching a sounding rocket to an altitude of 500 kilometers.[224]

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[220] Joseph S. Tulchin, "Argentine Strategic Culture" (presented at the Argentina Strategic Culture Workshop, Florida International University, 2010), 3–4.

[221] Pablo De León, *Historia De La Actividad Espacial En La Argentina* [*History of Argentine Space Activities*] (United States: Pablo de León, 2010), 106–07.

[222] Alberto Marcelo Viscardi, *El Programa Espacial Argentino, 1960–2008: Un Análisis de Largo Plazo* [*The Argentine Space Program, 1960–2008: A Long-Term Analysis*], Documento de Trabajo (La Plata: Universidad Nacional de La Plata, 2010), 5, http://sedici.unlp.edu.ar/bitstream/handle/10915/1813/Documento_completo.pdf?sequence=1.

[223] Leonado Moledo, "Un Pequeño Salto Para El Mono [A Small Leap for a Monkey]," Página 21, December 30, 2009, http://www.pagina12.com.ar/diario/sociedad/3-137821-2009-12-30.html.

[224] Viscardi, *El Programa Espacial Argentino*, 6.

The growing influence of the military in government helped shield CNIE from the tumultuous political landscape during the first two decades of CNIE's existence, allowing it to be successful. *Coup d'états* occurred frequently as power changed hands between right- and left-wing political parties. The coup of 1976 ushered in the most repressive and violent era in Argentine politics. Between 1976 and 1983, a period known as the National Reorganization Process, the military also took over the strategic direction of CNIE and started the *Cóndor* ballistic missile project.[225]

The Argentine defeat in the Falklands/Malvinas War of 1982 discredited the military, ushering in an era of democracy. This also embittered Argentina against the United States. The Argentine military miscalculated that the United States would support them. With the Beagle Islands border dispute between Chile and Argentine resolved in 1984 and no other real regional threats, the Argentine military struggled to redefine itself. Argentina continued the development of the *Cóndor II* ballistic missile project to maintain relevance. To accomplish this, President Raúl Alfonsín struck a secret deal with Iraq and Egypt to help fund the project in exchange for the technology.[226] U.S. intelligence leaked information about the project to apply pressure through the MCTR (which Argentina would join in 1993).[227] Ultimately, faced with the economic downturn of the 1980s, Argentina decided to discontinue the program rather than risk losing U.S. support to restructure its foreign debt.[228]

On 28 May 1991, President Carlos Menem issued a decree dissolving CNIE, creating the *Comisión Nacional de Actividades Espaciales* (National Commission of Space Activities [CONAE]), and terminating the *Cóndor II* project all in one law.[229] The law placed CONAE directly under the Office of the President, officially divesting the

[225] Harding, *Space Policy in Developing Countries*, 149.

[226] Escudé, "Argentina and the Cóndor II Missile Project," 57.

[227] Bowen, *The Politics of Ballistic Missile Nonproliferation*, 43–44.

[228] Escudé, "Argentina and the Cóndor II Missile Project," 57.

[229] Carlos Menem, "Decreto Nacional 995/91: Creación de La Comisión Nacional de Actividades Espaciales [Decree 995/91: Creation of the National Committee on Space Activities]," *Secretaría de Ambiente Y Desarrollo Sustentable*, May 28, 1991, http://www2.medioambiente.gov.ar/mlegal/participa/dec995_91.htm.

military of control over the space program. This action was mild in comparison to other actions taken to subject Argentina's military to civilian rule. Zoltan Barany argues that no other Latin American country punished its military to the extent Argentina did.[230] Granted, the human rights abuses seen in Argentina surpassed those of other countries. In 1996, CONAE shifted to the *Ministerio de Relaciones Exteriores, Comercio Internacional y Culto* (Ministry of Foreign Affairs, International Trade and Worship). As of 14 November 2012, CONAE now resides in the *Ministerio de Planificación Federal, Inversión Pública y Servicios* (Ministry of Federal Planning, Public Investment and Services).[231]

Although the new Argentine democracy stripped control of the space program from the military, it did not entirely eliminate its participation. In 1991, the *Escuela de Ingeniería Aeronáutica* (School of Aeronautical Engineering), run by the FAA, merged with the IIAE to form a new institution: the *Instituto Univerisitario Aeronáutico* (Aeronautical Graduate Institute).[232] Here many of the engineers that previously worked on the Cóndor project began work on a small satellite, *μSAT-1* (*Víctor*). *Víctor* launched successfully from Russia's Plesetsk Cosmodrome on 29 August 1996, becoming the first satellite completely designed, built, and flight qualified by Argentine professionals.[233]

Víctor, however, was not Argetina's first satellite. This honor belongs to *LUSAT-1*, an amateur radio satellite launched aboard an Arianne booster from French Guyana on 21 January 1990. *LUSAT-1* used the Radio Amateur Satellite Corporation (AMSAT) OSCAR (short for "Orbiting Satellite Carrying Amateur Radio") design and was

[230] Zoltan D. Barany, *The Soldier and the Changing State: Building Democratic Armies in Africa, Asia, Europe, and the Americas* (Princeton, N.J.: Princeton University Press, 2012), 143.

[231] Comisión Nacional de Actividades Espaciales, "Antecedentes [History]," *Comisión Nacional de Actividades Espaciales*, accessed November 14, 2014, http://www.conae.gov.ar/index.php/espanol/sobre-conae/quienes-somos/antecedentes.

[232] La Cámara de Diputados de la Nación, "Proyecto de Resolucion [Draft Resolution]," December 7, 2007, http://www.hcdn.gov.ar/proyectos/proyecto.jsp?id=87809.

[233] Héctor H. Brito and Luis A. Murgio, "El Proyecto Microsat : Primer Satélite Argentino En Orbita [The Micro-Satellite Project: First Argentine Satellite in Orbit]," *Cienca Hoy* 8, no. 47 (December 1997), http://www.cienciahoy.org.ar/ch/hoy43/micros1.htm.

constructed in the United States on behalf of the Argentine chapter of AMSAT.[234] Even 25 years later amateur radio enthusiasts have been able to receive faint signals from *LUSAT-1*.[235] The 1990s also saw a thawing of relations between the United States and Argentina. Guido Di Tella, Argentina's foreign minister at the time, famously described Argentina's policy of engagement with the United States as "*relaciones carnales*" (carnal relations).[236] Argentina ratified the Treaty of Tlateloclo (1995) and signed the NPT (1995). President Menem also infused the space program with US$700 million in 1994.[237] Collaboration between CONAE, NASA, and other international partners gave rise to the *Satélites de Aplicación Científica* (Scientific Applications Satellite [SAC]) Program. Argentina, Brazil, Italy, and the United States collaborated on the first of these satellites, *SAC-B* (launched ahead of *SAC-A*), to measure gamma rays. Argentina led the design, construction, and systems integration of the satellite, with Italy providing solar panels, the Unites States developing two scientific instruments, and Brazil performing the qualification testing at INPE.[238] Unfortunately, in 1996, the U.S. Pegasus launch vehicle carrying *SAC-B* failed and the satellite was lost.

The success of *SAC-A* quickly followed the failure of *SAC-B*. Argentina designed and built *SAC-A* as a technology test-bed for the more complex Earth-observing satellite, SAC-*C*. Space Shuttle Endeavour (STS-88) successfully inserted *SAC-A* into orbit in December of 1998.[239] For the SAC-C mission, Argentina once again participated in an international team, comprised of Brazil, Denmark, France, Italy, and the United States.

[234] Marcelino García, "AMSAT Argentina LUSAT-1: Manual Del Satélite [AMSAT Argentina LUSAT-1: Satellite Manual]," February 18, 1990, http://lusat.org.ar/LUSAT4.pdf.

[235] American Radio Relay League, "Venerable LUSAT-1 (OSCAR 19) Goes to the Dark Side," August 8, 2014, http://www.arrl.org/news/venerable-lusat-1-oscar-19-takes-to-the-dark-side.

[236] Argentina.ar, "Relaciones Carnales: El Vínculo Con Estados Unidos En La Década Del 90 [Carnal Relations: The Link with the United States During the 1990s]," May 5, 2013, http://www.argentina.ar/temas/democracia-30-anos/24129-relaciones-carnales-el-vinculo-con-estados-unidos-en-los-90.

[237] Harding, *Space Policy in Developing Countries*, 150.

[238] Comisión Nacional de Actividades Espaciales, "SAC-B Participación Internacional [SAC-B International Participation]," accessed November 15, 2014, http://www.conae.gov.ar/index.php/espanol/misiones-satelitales/sac-b/participacion-internacional.

[239] Comisión Nacional de Actividades Espaciales, "SAC-A Objetivos [SAC-A Objectives]," accessed November 15, 2014, http://www.conae.gov.ar/index.php/espanol/misiones-satelitales/sac-a/objetivos.

The satellite worked in concert with *Landsat 7*, *EO-1*, and *TERRA* imaging the Earth with different resolutions and spectral bands. *SAC-C* launched successfully from Vandenberg Air Force Base aboard a Delta II rocket on 21 November 2000, and ended its mission on 15 August 2013—over 4 years beyond its expected lifetime.[240] Finally, CONAE played a contributing role in *SAC-D/Aquarius* (launched 10 June 2011), providing several scientific instruments. In all of these projects, CONAE relied heavily on INVAP S.E., a state-run technology corporation.[241] All of these projects support CONAE's strategic vision as expressed in the most recent revision of the *Plan Espacial Nacional* (National Space Plan).[242]

Progress toward GEO satellites has been slower, but no less successful. A multination consortium composed of European Aeronautic Defense and Space Company (EADS, aka Airbus Group) and the Italian company Finmeccanica constructed Argentina's first GEO communications satellite, *NAHUEL-1A*, which launched on 30 January 1997.[243] In 2006, Argentina created a state-owned company, *Empresa Argentina de Soluciones Satelitales* (Argentine Satellite Solutions Company [AR-SAT]) that took over the operation of the former Nahuelsat consortium.[244] Like CONAE, AR-SAT turned to INVAP to design and fabricate the satellite. On 16 October 2014, an Ariane 5 launch vehicle successfully inserted *ARSAT-1* into GEO, representing the first GEO satellite designed and built entirely in Latin America.[245]

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[240] Comisión Nacional de Actividades Espaciales, "SAC-C Objetivos [SAC-C Objectives]," accessed November 15, 2014, http://www.conae.gov.ar/index.php/espanol/misiones-satelitales/sac-c/objetivos.

[241] Harding, *Space Policy in Developing Countries*, 150.

[242] Comisión Nacional de Actividades Espaciales, "Plan Espacial Nacional: Argentina En El Espacio [National Space Plan: Argentina in Space]," 2010, 58–61.

[243] Ricardo A. de Dicco, *ARSAT-1: Primer Satélite de Telecomunicaciones Desarrollado En Argentina [ARSAT-1: First Telecommunications Satellite Developed in Argentina]* (Buenos Aires, Argentina: Centro Latinoamericano de Investigaciones Científicas y Técnicas, March 2009), 1.

[244] Ibid., 2.

[245] Comisión Nacional de Actividades Espaciales, "La CONAE Felicita a ARSAT Por El Lanzamiento Exitoso Del ARSAT-1, El Primer Satélite de Telecomunicaciones Argentino [CONAE Congratulates ARSAT on the Sucessful Launch of ARSAT-1, the First Argentine Telecommunications Satellite]," October 17, 2014, http://www.conae.gov.ar/index.php/espanol/2014/719-arsat-1-el-primer-satelite-de-telecomunicaciones-argentino.

Argentina has also been able to make progress toward a small-payload LEO launch vehicle. Building on the expertise developed during the Cóndor II project, as well as the successful collaboration with Brazil on the VS-30 sounding rocket in 2007, CONAE embarked on the Tronador project.[246] In 2011, a design failure of the first prototype led to the current project, Tronador II. In August of 2014, the program successfully tested subsystems of the Tronador II in a short 27-second flight reaching an altitude of 2,200 meters.[247] In 2013, the press reported that the first orbital test of the Tronador II might occur in September of 2015; however, CONAE has not announced an official date, pending more testing.[248]

Since the Kirtchners came to power after Argentina's financial crisis in the late 1990s and early 2000s, the U.S.-Argentine relationship has cooled. The relationship soured further when two U.S. firms refused to restructure US$1.3 billion in debt.[249] In 2005, *Latinobarómetro* reported that only 32 percent of Argentines had a good opinion of the United States, the lowest in Latin America.[250] Many in Argentina viewed the financial meltdown as a direct result of the neoliberal economic reforms required by the International Monetary Fund and the World Bank. Since this downturn of opinion, no additional NASA collaboration has been announced beyond the *SAC-D/Aquarius* mission.

Instead, CONAE has been reaching out to other partners. CONAE announced a joint mission with Brazil (AEB and INPE) on an ocean-observation mission named *Satélite Argentino Brasileño para Información del Mar* (Argentine Brazilian Satellite for

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[246] Harding, *Space Policy in Developing Countries*, 151–152.

[247] Comisión Nacional de Actividades Espaciales, "Tronador II," *Comisión Nacional de Actividades Espaciales*, accessed November 15, 2014, http://www.conae.gov.ar/index.php/espanol/acceso-al-espacio/tronador-ii.

[248] Patricia Rey Mallén, "Argentina To Put First Satellite In Space Using Own Launch Technology By 2015," *International Business Times*, November 14, 2013, http://www.ibtimes.com/argentina-put-first-satellite-space-using-own-launch-technology-2015-1471090.

[249] BBC News, "Argentina Loses $1.3bn Debt Appeal," BBC News, August 25, 2013, http://www.bbc.co.uk/news/business-23832247.

[250] Janie Hulse, *China's Expansion into and U.S. Withdrawal from Argentina's Telecommunications and Space Industries and the Implications for U.S. National Security* (Carlisle, PA: Strategic Studies Institute, U.S. Army War College, 2007), 42.

Sea Information, or *SABIA-Mar*). COBAE has also announced a joint project with Italy on the *Satélite Argentino de Observación Con Microondas* (Argentine Microware Sounding Satellite, or *SAOCOM*). The primary mission is to measure soil moisture using microwave synthetic aperture radar. The first of the series is scheduled for a 2015 launch.[251]

Finally, in 2004, Argentina signed an agreement with China to cooperate in space on peaceful projects; however, little came of this until recently. In September of 2014, China and Argentina reached an agreement to allow China to install a deep-space antenna in Argentina's Patagonia region. The deal is shrouded in secrecy, raising suspicions about the intended use of the facility, given the dual military/civilian use of the antenna.[252] Furthermore, Argentina is deeply indebted to China. Argentina has been unable to raise money through bonds after it defaulted on domestic bonds in 2002 in the wake of its financial crisis. Argentina has reached out to China and Russia to help ease its crisis.[253] Argentina's continuing financial problems may dampen further space efforts as the political opposition to the Kirchner administration points out the high cost of *ARSAT-1* (US$270 million).[254]

As expected given the similarity between the two programs, Argentina's space program shares many of the themes of Brazil's space program. Argentina's transition to democracy effectively ended geopolitical competition with Brazil. The effort to bring the military under civilian control reduced military involvement in the program, but did not eliminate it. The Kirchner regime (both Néstor and Christina), however, have continued the humiliation of the military in a way that goes beyond holding individuals responsible

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[251] Comisión Nacional de Actividades Espaciales, "SAOCOM Introducción [SAOCOM Introduction]," *Comisión Nacional de Actividades Espaciales*, accessed November 15, 2014, http://www.conae.gov.ar/index.php/espanol/misiones-satelitales/saocom/objetivos.

[252] MercoPress, "China Constructing a Satellite Tracking Station in Argentine Patagonia," *MercoPress*, September 12, 2014, http://en.mercopress.com/2014/09/12/china-constructing-a-satellite-tracking-station-in-argentine-patagonia.

[253] Benedict Mander, "Argentina Looks to China and Russia for Support," FT.com, July 10, 2014, http://www.ft.com/intl/cms/s/0/7d88a8de-083e-11e4-acd8-00144feab7de.html#axzz3JAgXSqTO.

[254] MercoPress, "Argentina Launches Satellite and Cristina Fernandez Slams Opposition over Negative Attitude," accessed October 23, 2014, http://en.mercopress.com/2014/10/17/argentina-launches-satellite-and-cristina-fernandez-slams-opposition-over-negative-attitude.

for human rights violations.[255] In Latin America, Argentina currently collaborates with Brazil and is looking to work with Bolivia in the future.[256] The MTCR also impeded early launcher development in Argentina. CONAE currently resides in the Ministry of Federal Planning, Public Investment and Services, which emphasizes its focus on economic development. Argentina's current National Space Plan is due for an update in 2015. For now, Argentina's tenuous economic situation may limit the pace of progress in the future.

B. VENEZUELA

Venezuela shares the same challenges with geography as its other Andean Pact nations—Bolivia, Colombia, Ecuador, and Peru. The mountainous terrain of the Andes drives up the cost of building telecommunications infrastructure, making space-based communications an attractive option. In the 1980s, the Andean Pact nations studied the possibility of acquiring a GEO satellite to meet their telecommunications needs; however, the effort failed due to the financial difficulties experienced by most South American countries during the debt crisis of the 1980s.[257] The project resumed in the late 1990s under the name *Simón Bolívar Satellite System*. When the company ANDESAT S.A., representing the consortium of Andean nations and its investors, failed to meet its deadlines, the agreement was cancelled, leaving the GEO orbital slot designated for it entangled in legal issues.[258]

The Venezuelan constitution, drafted shortly after Hugo Chávez's rise to power in 1999, asserted Venezuela's right to use space for peaceful purposes in accordance with international agreements. The constitution also paved the way for new institutions,

[255] Barany, *The Soldier and the Changing State*, 156–57.

[256] Comisión Nacional de Actividades Espaciales, "Visita Oficial de La CONAE, ARSAT E INVAP Para Impulsar La Cooperación Con La Agencia Boliviana Espacial [Official Visit of CONAE, ARSAT, and INVAP to Promote Cooperation with the Bolivian Space Agency]," September 10, 2014, http://www.conae.gov.ar/index.php/espanol/2014/710-visita-oficial-de-la-conae-arsat-e-invap-para-impulsar-la-cooperacion-con-la-agencia-boliviana-espacial.

[257] Harding, *Space Policy in Developing Countries*, 159.

[258] Juan José Taccone and Uziel Nogeira, eds., *Andean Report No. 2* (Buenos Aires, Argentina: Inter-American Development Bank, 2005), 81, http://idbdocs.iadb.org/wsdocs/getdocument.aspx?docnum=33036507.

including the new *Ministerio del Poder Popular para Ciencia, Tecnología e Industrias Intermedias* (Ministry of Popular Power for Science, Technology, and Intermediate Industries) that oversaw space activities. Among its other activities, the ministry served as Venezuela's first national-level space commission. In 2005, acting on the recommendations of a presidential committee headed by the ministry, President Chávez formed the *Centro Espacial Venezolano* (Venezuelan Space Center [CEV]), which became the *Agencia Bolivariana para Actividades Espaciales* (Bolivarian Agency for Space Activities, ABAE) in 2007.[259] The name of Venezuela's space agency gives a strong sense of the character of Chávez's nationalism. The activities of ABAE are organized along four, by now familiar, themes:

> Promote the peaceful uses of outer space and technological development for life and peace; promote the development and growth of space capabilities in Venezuela through technology transfer and human training in order to achieve technological independence; coordinate and use space science and technology to satisfy social needs and support national programs; [and] promote regional integration and cooperation.[260]

The emphasis on technology transfer and development of human capital is evident in ABAE's effort to acquire satellite technology.

In 2005, the CEV signed an agreement with the China's CGWIC to design, fabricate, and launch a GEO communications satellite, build two ground stations, and train Venezuelan technicians to operate the stations. On 29 October 2008, China successfully launched the *Simón Bolivar Satellite* (designated *VENESAT-1)*. As a result of the deal, 30 Venezuelan scientists and engineers received doctorates and 60 satellite technicians were trained at China's Beihang University and the Chinese Academy of Space Technology (CAST).[261] Aside from the telecommunications mission of the satellite, Venezuela also uses *VENESAT-1* for several state social programs to include

[259] Acevedo et al., "Space Activities in the Bolivarian Republic of Venezuela," 175.

[260] Ibid., 176.

[261] Ibid., 177.

telemedicine for citizens in remote areas, and disaster management.[262] The total project cost US$406 million, of which the satellite itself cost US$241 million.[263]

Venezuela signed a second agreement with the CGWIC in May 2011 to produce an Earth-observing satellite similar to Brazil's CBERS satellites. Venezuela named its second satellite after Francisco de Miranda, an early advocate of independence from Spain.[264] As part of the deal, CAST trained 52 Venezuelans in remote sensing.[265] China successfully launched the satellite, officially designated the *Venezuelan Remote Sensing Satellite-1* (*VRSS-1*), on 29 September 2012. *VRSS-1* cost approximately US$140 million.

The death of Chávez has not slowed Venezuela's space activities. On 5 October 2014, President Maduro signed a third agreement with CGWIC to build *VRSS-2*. Keeping with Venezuela's tradition, this satellite will be named after Antonio José de Sucre, the leader of the Venezuelan independence movement.[266] Venezuela plans to invest US$170 million into this project, which is expected to take three years to complete. As part of the deal, CGWIC will collaborate with Venezuela in assembling the satellite in Venezuela. In preparation for this, Venezuela plans to inaugurate the *Centro de Investigación y Desarrollo Espacial* (Center for Space Research and Development) in the latter half of 2015.[267] The center will focus on small satellite technology.[268] Venezuela has also

[262] R. Acevedo, F. Varela, and N. Orihuela, "The Role of Venesat-1 Satellite in Promoting Development in Venezuela and Latin America," *Space Policy* 26, no. 3 (August 2010): 190, doi:10.1016/j.spacepol.2010.05.003.

[263] Harding, *Space Policy in Developing Countries*, 161.

[264] Stephen Clark, "China Launches Earth-Observing Satellite for Venezuela," Space.com, October 1, 2012, http://www.space.com/17849-china-satellite-launch-venezuela.html.

[265] R. Hernández et al., "Current Space Projects of the Bolivarian Republic of Venezuela," *Revista Mexicana de Astronomía Y Astrofísica* 23, (2014), 11, http://www.redalyc.org/resumen.oa?id=57131045004.

[266] Peter B. de Selding, "China, Venezuela To Collaborate on New Earth Observing Satellite," Space News, October 7, 2014, http://www.spacenews.com/article/civil-space/42109china-venezuela-to-collaborate-on-new-earth-observing-satellite.

[267] Edward Castillo, "Programa Satelital VRSS-2 'Antonio José de Sucre' Será Diseñado Y Ensamblado Con Profesionales de Venezuela Y China [The VRSS-2 'Antonio José de Sucre' Satellite Will Be Developed Designed and Assembled by Venezuelan and Chinese Professionals]," *Ministerio Del Poder Popular Para Ciencia, Tecnología E Innovación*, October 6, 2014, http://www.mcti.gob.ve/actualidad/noticias/programa-satelital-vrss-2-antonio-jose-de-sucre-sera-disenado-y-ensamblado-con.

[268] Hernández et al., "Current Space Projects of the Bolivarian Republic of Venezuela," 12.

reached out to France, India, and the United Kingdom to train Venezuelan space professionals. In all, about 200 Venezuelans have been trained in remote sensing, project management, satellite design, and space insurance.[269]

Venezuela is methodically moving up the Space Technology Ladder. ABAE reinforces these gains by emphasizing technology transfer and the creation of human capital to support its activities. The early acquisition of a GEO communications satellite by Venezuela is as much driven by the complicated geography of the Andes as the need to expand the audience of the strategic communication of the Bolivarian revolution. As an example, *VENESAT-1* carried President Chávez's Sunday talk show, *Aló President*, to much of the Caribbean and Central and South America.[270] President Correa of Ecuador and President Morales of Bolivia have copied Chávez with programs of their own as well.[271] Victor Cano, president of ABAE, stated the following:

> Our idea is to strengthen ourselves as a nation in the space industry but also rely on other countries within the region, such as Argentina and Brazil, which have already built several satellites and have more years of experience than us. In addition, we also support other countries, such as Bolivia, that are starting to delve in the space industry.[272]

The acquisition of *VRSS-1* and Venzuela's focus on remote sensing reflects Venzuela's desire to minimize U.S. influence, and at the same time strengthens ties with China, Europe, and India, all of whom are educating Venezuelan personnel. Thus, ABAE serves a clear domestic, regional, and international purpose.

Domestic economic problems may threaten the Venezuelan space program. The sharp drop in oil prices beginning in October 2014 threatens the solvency of the Venezuelan government. As of December 2014 the price of oil dropped to roughly US$60 per barrel. Venezuela requires a price of at least US$117 per barrel to import

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[269] Ibid., 11.

[270] Harding, *Space Policy in Developing Countries*, 161.

[271] "Chavez TV Show Marks Anniversary," BBC, May 24, 2009, http://news.bbc.co.uk/2/hi/americas/8066511.stm.

[272] Veronica Magan, "Venezuela: Latin America's Next Space Pioneer?," Via Satellite, August 23, 2013, http://www.satellitetoday.com/publications/2013/08/23/venezuela-latin-americas-next-space-pioneer-2/.

needed goods and services and to stave off default on its debt.[273] Roughly 96 percent of Venezuela's export revenue comes from oil and Venezuela uses oil to pay off its debts to China, which now total more than US$10 billion.[274] With annual inflation above 60 percent and popular support for President Maduro eroding, an extended period of low oil prices will threaten the stability of regime.[275]

C. MEXICO

Like Brazil, Mexico also enjoyed an earlier collaboration with NASA in the space age, including tracking Project Mercury flights.[276] Mexico already had an active civilian rocketry program. A group of students from the *Universidad Autónoma de San Luis Potosí* (Autonomous University of San Luis Potosí) led by Dr. Gustavo del Castillo y Gama launched Física-1 (Physics-1), Mexico's first sounding rocket launch on 28 December 1957. The rocket reached an altitude of 4 kilometers.[277]

Walter C. Buchanan, an American-trained engineer and head of the *Secretaría de Comunicaciones y Transportes* (Communications and Transportation Secretariat, SCT), commissioned two sounding rockets, SCT-1 and SCT-2, based on the German *V-2* design. On 24 October 1959, SCT-1 launched and reached an altitude of 4,000 meters before strong winds forced it into a horizontal trajectory. SCT-2 launched on 1 October 1960, reaching an altitude of 25 kilometers.[278] Buoyed by this success, Buchanan was instrumental in the creation of Mexico's national space committee: the *Comisión*

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[273] Andres Schipani and John Paul Rathbone, "Venezuela Loses Faith in Socialist Government," *Ft.com*, December 11, 2014, http://www.ft.com/intl/cms/s/0/4a965a04-7be1-11e4-a695-00144feabdc0.html#axzz3Lp41SaEj.

[274] Sara Schaefer Muñoz and Ezequiel Minaya, "Venezuela Vulnerable to Oil's Fall," *Wall Street Journal*, October 17, 2014, sec. World, http://online.wsj.com/articles/venezuela-vulnerable-to-oils-fall-1413540003.

[275] Girish Gupta, "Could Low Oil Prices End Venezuela's Revolution?," *The New Yorker*, November 3, 2014, http://www.newyorker.com/business/currency/will-low-oil-prices-end-venezuelas-revolution.

[276] Harding, *Space Policy in Developing Countries*, 155.

[277] Carlos Duarte, "Hacia El Espacio [Towards Space]," Hacia El Espacio, October 2013, http://haciaelespacio.wix.com/haciaelespacio007.

[278] P. B. Buitron, *Translation of "La Construccion Y El Lanzamiento de Los Cohetes SCT-1 Y SCT-2" ["The Construction and Launch of SCT-1 and SCT-2"]* (Washington, D.C.: National Aeronautics and Space Administration, 1963), 9, 13, http://ia700701.us.archive.org/33/items/nasa_techdoc_19660017744/19660017744.pdf.

Nacional del Espacio Exterior (National Commission on Outer Space [CONEE]) formed on 31 August 1962.[279]Between 1962 and 1977, CONEE capitalized on the success of the SCT launches to develop two series of sounding rockets (with Nahuatl translations): Tototl (bird) and, Mitl (arrow).[280] In 1962, TOTOTL reached an altitude of 22 kilometers. MITL 1 and MITL 2 achieved altitudes of 50 and 120 kilometers in 1976 and 1975, respectively.[281]

In 1968, Mexico founded the Satélites Mexicanos (Satmex) company to operate and manage its GEO satellites. Satmex was among the original companies forming the INTELSAT consortium.[282] In 1977, Mexican President José López Portillo dissolved CONEE and Mexico would remain without a dedicated space policy body until 2010. Although Mexico would continue to collaborate with NASA on satellite tracking, Mexico's progress in rocketry halted. In the interim years, Mexico pursued satellite technology. Mexico contracted with the Hughes Corporation to acquire its first telecommunications satellites. Space Shuttles *Discovery* and *Atlantis* carried *Morelos 1* (17 June 1985) and *Morelos 2* (27 November 1988), respectively, into orbit. Once released, a secondary booster placed each in GEO orbit. The *Atlantis* mission also holds the distinction of carrying Mexico's first astronaut, Rodolfo Neri Vela, into space.[283]

During the 1990s, students and researchers at the *Universidad Autónoma de México* (National Autonomous University of Mexico, UNAM) built an amateur radio satellite, *UNAMSAT-1*, using the AMSAT OSCAR design.[284] Unfortunately, on 28 March 1995, the Russian *Start-1* rocket failed, destroying the satellite. Undaunted, UNAM refurbished an engineering model to create *UNAMSAT-B*, which successfully

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[279] Enrique G. León López, "Fechas Relevantes - Biografías - Cross Buchanan," *Presidencia Del Decanato Del Intituto Politécnico Nacional*, accessed November 6, 2014, http://www.decanato.ipn.mx/central8b10.htm.

[280] Luis A. Pérez Benitez, "Agencia Espacial Mexicana, ¿a Coahuila? [Mexican Space Agency, To Coahuila?]," Infoespacial.com, February 23, 2011, http://www.infoespacial.com/?perspectiva=agencia-espacial-mexicana-%C2%BFa-coahuila.

[281] Ibid.

[282] Harding, *Space Policy in Developing Countries*, 155.

[283] Ibid.

[284] Belduque, "Los Satélites UNAM-SAT No Eran Mexicanos [The Satellite of UNAM-SAT Were Not Mexican]," June 27, 2011, http://www.info7.mx/a/noticia/276317.

launched on 5 September 1996 from Russia's Plesetsk Cosmodrome becoming Mexico's first and only LEO satellite. UNAM announced a plan to place another microsatellite in orbit; however, no additional information has been made public since.[285]

On 2 January 2014, the French company Eutelsat purchased Satmex and will take over the operation of Satmex's three GEO satellite currently in operation (*Satmex 5*, *6*, and *8).*[286] The SCT has also contracted with Boeing to construct two new GEO satellites, *Mexsat-1* and *2*. These satellites will modernize communications across the government, supporting the military, police, public health, and disaster relief. Mexico constructed two new satellite ground stations in Iztapalapa and Hermosillo to support these new assets.[287]

Most recently, a private group called the *Colectivo Espacial Mexicano* (Mexican Space Collective) developed *Ulises-1*, a nanosatellite with a radio beacon for amateur radio enthusiast to track. The project is described as a work of art with the goal of showing that if a small group of committed citizens can design and launch a satellite, then anything is possible. The Japanese Space Agency will carry the satellite into orbit aboard an ISS service module early in 2015.[288]

On 30 July 2010, Mexico established the *Agencia Espacial Mexicana* (Mexican Space Agency, AEM) to formulate Mexican space policy. The AEM is the result of nearly 20 years of lobbying by the Mexican space community represented by the *Sociedad Espacial Mexicana* (Mexican Space Society), a non-profit organization, as well as universities like UNAM and the *Universidad del Ejército y Fuerza Aérea Mexicana* (University of the Mexican Army and Air Force).[289]

[285] Gabriela Alvarez, "Los Satélites Mexicanos: Presente Y Futuro [Mexican Satellites: Present and Future]," FuturoMx, December 31, 2013, http://www.futuromx.com/home/secciones/innovacion/item/132-los-satelites-mexicanos-presente-y-futuro.html.

[286] Eutelsat, "Eutelsat Communications Concludes Acquisition of SATMEX," January 2, 2014, http://www.eutelsat.com/en/news/2014/Eutelsat-Satmex.html.

[287] Boeing, "Boeing: Mexsat," accessed November 6, 2014, http://www.boeing.com/boeing/defense-space/space/bss/factsheets/702/mexsat/mexsat.page.

[288] Coletivo Espacial Mexicana, "Ulises Is Going to Space!," accessed November 6, 2014, http://www.ulises1.mx/Ulises_1/Ulises_I.html; Coletivo Espacial Mexicana, "Lanzamiento 2014 [2014 Launch]," accessed November 6, 2014, http://www.ulises1.mx/Ulises_1/Lanzamiento.html.

[289] Agencia Espacial Mexicana, "Antecedentes de La Agencia Espacial Mexicana [History of the Mexican Space Agency]," accessed November 6, 2014, http://www.aem.gob.mx/index01-4.html.

The AEM published its vision for space over in *Programa Nacional de Actividades Espacial 2011–2015*. This document outlines five strategic areas of development that are aligned with Mexico's National Development Plan: development of human capital, scientific research and technology development, development of the industrial sector, international outreach, financing and management.[290] As the AEM presses forward with this initial vision, it is assessing the demand for space services across the government, academia, and industry. The AEM has also been active in reaching out to the United States, Canada, France, and others, opening doors to a variety of scientific exchanges. On 8 December 2014, the AEM announced an agreement with NASA to collaborate on advanced space communications systems for future Lunar and Mars missions.[291]

Early reports indicated that Mexico planned an US$80 million launch facility near the city of Chetumel on the Yucatan peninsula; however, there hasn't been any recent reporting on progress.[292] More recently, the AEM entered into an agreement with the German Space Agency to install a satellite ground station in Chatumel.[293] The AEM started with an annual budget of US$800,000 and is not expected to rise above US$8 million.[294] Thus, progress will be slow on activities not directly related to the acquisition of GEO satellites.

Like its South American counterparts, Mexico's space program is focused inwardly on development. Mexico's planned acquisition of two Boeing satellite indicates

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[290] Agencia Espacial Mexicana, *Programa Nacional de Actividades Espacial 2011–2015* [*National Program of Space Activities 2011–2015*] (México, D.F.: Secretaría de Comunicaciones y Transportes, 2012), 8–9.

[291] Agencia Espacial Mexicana, "Establece AEM Alianza Estratégica Con Nasa Para Desarrollo de Proyectos Con Uso de Telecomunicaciones Espaciales [AEM Establishes a Strtegic Alliance with NASA to Develop Space Telecommunications Projects," December 8, 2014, http://www.aem.gob.mx/notas/alianzaEstrategica.html.

[292] RIA Novosti, "Mexico to Create Its First Space Center on Yucatan Peninsula," April 22, 2010, http://en.ria.ru/world/20100422/158694450.html.

[293] Xinhua Español, "Operará Agencia Espacial Mexicana Antena de Telecomunicación Satelital [The Mexican Space Program Will Operate a Satellite Communications Antenna]," Xinhua, August 10, 2014, http://spanish.xinhuanet.com/tec/2014-08/10/c_133544890.htm.

[294] Antonio Regalado, "Mexico Gets a Space Agency," *Science*, April 22, 2010, http://news.sciencemag.org/2010/04/mexico-gets-space-agency.

Mexico's desire to improve its internal security. International outreach serves two purposes: it improves diplomatic relationships and is essential for the AEB to meet its stated goals. The AEM is a national-level space program that integrates its goals with the broader development goals of the nation. *UNAMSAT-B*, Mexico's first foray into the LEO realm, demonstrated the ability of Mexican higher education to construct a satellite in house, with some outside assistance with design. Mexico has also been active in procuring and maintaining GEO satellite capability, but has not attempted to move beyond procurement. Finally, Mexico has not announced any desire to pursue launch capability.

D. PERU

While Robert H. Goddard is credited with building and launching the first liquid-fueled rocket, historical evidence points to Peruvian scientist Pedro Paulet as the first to conceive of the liquid motor design in 1895.[295] In 1910, Paulet helped found the *Liga Pro Aviación* (Pro-Aviation League) that eventually became the *Fuerza Aérea del Peru* (Peruvian Air Force, FAP). Though Paulet's invention forms the foundation of modern rocketry today, Peru's accomplishments in space have been modest.

In 1974, Peru established the *Comisión Nacional de Investigación y Desarrollo Aeroespacial* (National Commission of Aerospace Research and Development, CONIDA). According to Law 20643, the purpose of CONIDA is five-fold: promote the peaceful use of space in Peru, conduct research with domestic and foreign partners, form collaborative agreements with other national and international space institutions, facilitate technology transfer and the development of human capital, and identify ways to use space technology to promote development and enhance security in Peru.[296] The final purpose hints at the close connection between CONIDA and the Peruvian Ministry of Defense. A

[295] Sara Madueño Paulet de Vásquez, "Pedro Paulet: Peruvian Space and Rocket Pioneer," *21st Century Science and Technology Magazine*, accessed December 15, 2014, http://www.21stcenturysciencetech.com/articles/winter01/paulet.html.

[296] Comisión Nacional de Investigación y Desarrollo Aeroespacial, "Portal CONIDA [CONIDA Gateway]," accessed November 7, 2014, http://www.conida.gob.pe/index.php.

look at the current leaders of CONIDA confirms this—most are active FAP officers.[297] CONIDA established a sounding rocket launch site at Punta Lobos (operated by the FAP), just south of Lima, and began collaborating with NASA on upper atmospheric research. Over the next decade, Peru participated in several sounding rocket campaigns with NASA including Project ANTARQUI (1975) and Project CONDOR (1983).[298]

By the mid-1980s, the *Sendero Luminoso* (Shining Path) had begun terrorizing the countryside, and border tensions between Ecuador and Peru erupted in armed conflict. During Fujimori's quasi-authoritarian regime, Abimael Guzmán, the leader of the *Sendero Luminoso*, was captured, drastically reducing the violence in the countryside. Peru also settled its border dispute with Ecuador after a brief armed conflict in 1995 (Cenepa War). President Fujimori attempted to purchase Scud-C missiles from North Korea but later abandoned the effort.[299] These struggles shrank space budgets, slowing progress on sounding rocket and satellite development. As an example, in 1997 CONIDA began designing a remote-sensing satellite, dubbed CONIDASAT. Due to budget constraints the team developed most of the components in house; however, the project was cancelled due to lack of funds in 2003.[300]

In the mid-2000s, Peru placed renewed emphasis on remote sensing. In 2005, Peru joined the Chinese-led Asia-Pacific Space Cooperation Organization (APSCO). APSCO is an international organization that, according to its website, promotes the peaceful use of space among its member states by cooperating on Earth observation and disaster management, space science research, and technology development.[301] The current member states are Bangladesh, China, Iran, Mongolia, Pakistan, Peru, Thailand,

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[297] Comisión Nacional de Investigación y Desarrollo Aeroespacial, "Directorio [Directory]," accessed November 7, 2014, http://www.conida.gob.pe/index.php?option=com_content&view=article&id=53&Itemid=62.

[298] Harding, *Space Policy in Developing Countries*, 156.

[299] Ibid., 157.

[300] J. Martin Canales Romero, "First Steps to Establish an Small Satellite Program in Peru," (paper presented at the SpaceOps Conference, Huntsville, AL, 2010), 4, http://arc.aiaa.org/doi/pdf/10.2514/6.2010-2043.

[301] APSCO, "Convention of the Asia-Pacific Space Cooperation Organization (APSCO)" (Beijing, China: APSCO, 2005), http://www.apsco.int/apscon/apSCO-AD/imapic/201261315125947542.pdf.

and Turkey. Membership in the organization gives members access to imagery of their own territories from the Small Multi-Mission Satellite Project.[302] Currently, this project consists of one satellite (*HJ-1A*) that successfully launched on 6 September 2008.[303] In preparation to receive and disseminate satellite data, Peru established the *Centro Nacional de Operación de Imágenes de Satélite* (National Center for Satellite Imagery Operations) in 2006.[304] The Ministry of Defense and the Ministry of the Environment are the prime users of satellite imagery, which is not surprising considering the continuing threat from drug trafficking organizations and illegal mining activities.

Peru's desire for its own imaging satellite is the focus of its recent activity. In April of 2014, the Peruvian Ministry of Defense announced its intention to purchase an Earth-observing satellite from Airbus Defense and Space for US$213 million.[305] This has generated some controversy within Peru due to the high cost and the allegations that the negotiations violated Peru's laws for transparency. Chile purchased the *Astrosat-100* for US$72 million. Although the *Astrosat-300* is more capable, some have questioned the large price difference. Others indicated that the sub-meter resolution of the satellite actually inhibits the use of the satellite for the large-area observations required to detect illegal activities, like illegal fishing.[306] The high-resolution requirement appears to be

[302] APSCO, "APSCO Council Rules of Procedure," accessed November 8, 2014, http://www.apsco.int/AboutApscosS.asp?LinkNameW1=Policies,_Rules_and_Regulations&LinkNameW2=Rules_and_Regulations&LinkCodeN3=1722&LinkCodeN=13.

[303] Chinese National Space Administration, "HJ-A/B of Environment and Disasters Monitoring Microsatellite Constellation Delivered to the Users," April 1, 2009, http://www.cnsa.gov.cn/n615709/n620682/n639462/168207.html.

[304] Romero, "First Steps to Establish an Small Satellite Program in Peru," 3–4.

[305] Infoespacial.com, "Perú compra a Francia el satélite Astrosat 300 [Peru Buys the French Astrosat 300 Satellite]," April 26, 2014, http://www.infoespacial.com/?noticia=peru-compra-a-francia-el-satelite-asrosat-300.

[306] Nosolosig, "Perú Compra Satélite de Observación Envuelto En Polémica [Peru's Observation Satellite Enveloped in a Polemic]," April 24, 2014, http://www.nosolosig.com/noticias/310-peru-compra-satelite-de-observacion-envuelto-en-polemica.

driven by technical requirements deemed classified by the FAP.[307] In addition, Peru will gain access to imagery from six French satellites during the lifetime of the satellite.[308]

The lack of transparency surrounding this satellite deal seems to reverse the vision expressed in Peru's space policy released in 2009. According to Harding, *La Política Espacial del Perú* (The Space Policy of Peru) appeared to diminish the role of the Peruvian military in the space program. The plan stated that "without science and technology the country cannot achieve development…and without development there is no security."[309] At the time of this writing, this document no longer appears on CONIDA's website, nor can any archived copy of it be found on the Internet. The document also does not appear to have been superseded by a new strategic plan. Given that CONIDA remains subordinate to the Ministry of Defense, it is clear that the military remains a key driver of the space program.

This is evident in the continued development of sounding rockets and CONIDA's potential collaboration with USSOUTHCOM. On 12 June 2013, Peru launched the first Paulet 1-B rocket, reaching an altitude of 15 kilometers. The Paulet 1-B is the first sounding rocket completely designed and built using Peruvian technology. The head of CONIDA at the time, Major General Mario Pimentel Higueras, stated that by 2020, CONIDA plans to test a rocket capable of attaining 300 kilometers in altitude as a stepping stone to having a launcher with orbital capability.[310] As mentioned in the previous chapter, Peru, Brazil, and Chile have expressed interest in participating with USSOUTHCOM on the SNaP-3 satellite program.

[307] Peter Watson, "El Congreso del Perú solicita precisiones sobre compra del satélite Astrosat 300 [The Peruvian Congress Requests Calrifications Regarding the Purchase of the Astrosat 300 Satellite]," Infodefensa.com, August 27, 2008, http://www.infodefensa.com/latam/2014/08/27/noticia-congreso-solicita-precisiones-sobre-compra-satelite-astrosat.html.

[308] Miguel Gutiérrez R., "El Perú, a Solo Un Paso de Conquistar El Espacio [Peru, Just One Step From Conquering Space]," LaRepublica.pe, August 6, 2014, http://www.larepublica.pe/06-08-2014/el-peru-a-solo-un-paso-de-conquistar-el-espacio.

[309] Harding, *Space Policy in Developing Countries*, 158.

[310] Peru21, "Primer Cohete-Sonda Peruano Fue Lanzado Con Éxito En Pucusana," June 12, 2013, http://peru21.pe/tecnologia/primer-cohete-sonda-peruano-fue-lanzado-exito-pucusana-2135445.

Like other Latin American countries, Peruvian universities are experimenting with small satellites. The *Pontificia Universidad Católica del Perú* (Pontifical Catholic University of Peru, PUCP) constructed Peru's first two satellites to enter orbit. Constructed by the *Instituto de Radioastronomía* (Radio Astronomy Institute, INRAS), *PUCP-SAT 1* used a CubeSat design and carried an even smaller satellite, *Pocket-PUCP*, to be deployed on orbit. The INRAS team integrated both satellites aboard the Italian *Unisat-5*, which was successfully launched aboard a Russian Dnepr rocket from the Dombarovsky Cosmodrome on 24 October 2013.

Within a year of the launch of *PUCP-SAT 1*, Peru experienced a flurry of small satellite success. On 9 January 2014 *UAPSAT-1* launched from NASA's Wallops Island aboard an Orbital Sciences Antares rocket. Students and professors at *Universidad Alas Peruanas* (Peruvian Wings University, UAP) designed the satellite. Most recently, a team from the *Universidad Nacional de Ingeniería* (National University of Engineering) repeated this success with the deployment of another CubeSat, *Chasqui-1*, deployed by a cosmonaut on the ISS on 18 August 2014.[311]

Although Peru established CONIDA in 1974, progress along the Space Technology Ladder has been slow due to internal and external conflict. Despite this, Peru's focused approach has produced results, especially in gaining access to satellite imagery. Peru's universities are also using small satellites to build human capital to support space operations.

E. CHILE

Like Brazil, early Chilean space activities began with satellite tracking stations. In 1959, the University of Chile created the *Centro de Estudios Espaciales* (Center for Space Studies) as part of an agreement with NASA to assist with satellite tracking. This became the center's specialty for over 40 years, supporting many NASA missions including those in the Apollo series.[312] Unlike in Brazil, however, the Chilean military

[311] Miriam Kramer, "Spacewalking Cosmonaut Tosses Tiny Satellite Into Space for Peru," Space.com, August 18, 2014, http://www.space.com/26841-spacewalking-cosmonaut-launches-peru-satellite-video.html.

[312] Harding, *Space Policy in Developing Countries*, 164.

did not have a prominent role in space during Chile's military dictatorship from 1973 to 1989. In May of 1991, the *Fuerza Aérea de Chile* (Chilean Air Force, FACh) created the *Centro de Estudios Aeronáuticos y del Espacio* (Center of Aeronautics and Space Studies). This center represents Chile's first national space office. The University continued its collaboration with NASA.

Rather than pursue launcher technology, the FAch announced in March of 1994 its intention to create the first Chilean-built satellite, *FASat-Alfa* (*Fuerza Aérea Satélite*).[313] The FACh contracted with Surrey Satellite Technology Limited (SSTL) to build the satellite, transferring the technology to Chile and arranging graduate-level training for 15 Chilean engineers.[314] The satellite carried several scientific payloads, including an ozone-monitoring sensor and two camera systems.[315] Unfortunately, the satellite failed to deploy on orbit and was lost. The FACh contracted to produce the identical *FASat-Bravo.* This satellite launched from the Baikonur Cosmodrome on 10 July 1998 and operated successfully for three years before its batteries failed.[316]

In 2001, working on the recommendation of a space exploratory committee led by the FACh, President Lagos signed the decree creating the *Agencia Chilena del Espacio* (Chilean Space Agency [ACE]) as a presidential advisory committee. According to the decree, the primary function of ACE was to promote the internal development of the country, to demonstrate Chile's intentions to use space peacefully, and to promote international outreach in space. Like the AEB, ACE unites a multi-ministry committee across the Chilean government to coordinate space activities. Although led by the head of the *Comisión Nacional de Investigación Científica y Tecnológica* (National Commission

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313 Fuerza Aérea de Chile, "La Fuerza Aérea de Chile Informa Sobre El Desarrollo Del 1er. Satélite Chileno [The Chilean Air Force Announces the Development of the FIrst Chilean Satellite]," accessed October 25, 2014, http://www.fasat.aviacion.cl/Docs/info0194.pdf.

314 Surrey Satellite Technology Limited, "FASat-A Mission Page from SSTL," accessed October 26, 2014, http://www.sstl.co.uk/Missions/FASat-A--Launched-1995/FASat-A/FASat-A--The-Mission.

315 Earth Observation Portal, "FASat-Bravo," accessed October 26, 2014, https://directory.eoportal.org/web/eoportal/satellite-missions/f/fasat-bravo.

316 Ibid.

of Scientific and Technological Research), a civilian, the agency depended of the FACh for its technical and administrative support.[317]

ACE successfully procured an Earth-observing satellite through its *Sistema Satelital de Observación Terrestre* (Earth Observing Satellite System [SSOT]) program. The FACh contracted with EADS for US$72 million to develop and launch the satellite known as FASat-*charlie*.[318] The package deal also included establishing a grounds station, as well as allowing Chilean engineers to participate with EADS in the development of the satellite.[319] The satellite launched successfully into a LEO orbit from French Guyana on 17 December 2011. The system provides high-resolution images for military intelligence and civilian purposes, including management of agricultural lands and disaster monitoring.[320]

Chilean universities have also pursued small satellite projects. In 1994, the *Universidad de La Frontera* started work on the *Chile Satélite de Aficionados a las Radiocomunicaciones* (Chilean Satellite for Radio Communications Aficionados) or *AMSAT-CE* as it came to be known. The projected total cost of the satellite development was $575,000; however, it appears that the project is now defunct. The University of Chile is also developing a micro-satellite called *SUCHAI* (Satellite of the University of Chile for Aerospace Investigation). As of the latest status update in May 2014, the team traveled to INPE, in Brazil, to run preliminary acceptance tests; however, no launch provider has been announced.[321]

In 2012, the political difficulties of ACE began to surface in the press. In January of 2012, *El Mercurio*, a Chilean newspaper, reported that ACE no longer had a budget,

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317 Ricardo Lagos Escobar, "Decreto 338: Crea Comision Asesora Presidential Denominada Agencia Chilena Del Espacio [Decree 338: Create Presidential Accessory Committee Designated Chilean Space Agency]," Leychile.cl, July 17, 2001, http://www.leychile.cl/Navegar?idNorma=188592.

318 Harding, *Space Policy in Developing Countries*, 164.

319 Earth Observation Portal, "SSOT," accessed November 29, 2014, https://directory.eoportal.org/web/eoportal/satellite-missions/s/ssot.

320 Arianespace, "Orbiting Earth Observation Spacecraft" (Arianespace), accessed October 28, 2014, http://www.arianespace.com/images/launch-kits/launch-kit-pdf-eng/VS02-launchkit-GB.pdf.

321 Carlos González, "Testing SUCHAI Satellite at INPE, Brasil," Space and Planetary Excploration Laboratory, May 14, 2014, http://spel.ing.uchile.cl/test_brasil.html.

and its employees had been reassigned to other tasks.[322] According to the news report, the first Bachelet administration did not properly publish the decree officially transferring ACE to civilian control, making it invalid. Inexplicably, the Piñera adminstration took no immediate action to correct the error. By mid 2013, ACE no longer had a presence on the Internet.[323] In September of 2013, the *Ministério de Transportes and Telecomunicaciones* (Ministry of Transportation and Telecommunications, MTT) announced a public forum, in association with a multi-ministry effort, to discuss the future of the Chilean space program. In the resulting document *Política Nacional Espacial 2014–2020*, the *Subsecretaría de Telecomunicaciones* (Subsecretariat of Telecommunications) published this new vision for space development:

> By the year 2020, Chile will be a country that effectively takes advantage of the economic and social benefits from the use of space, with greater opportunities to develop knowledge, innovation, and entrepreneurship in space science and technology, with an environment conducive for progress in these activities and with space applications at the service of citizens, the workforce, and the government.[324]

To this end, Chile will pursue three paths. First, it will address the issues that led to the failure of ACE by creating a long-term vision for development and reforming the institutional and regulatory environment that impeded progress toward that vision.[325] The report suggests that due to its status as a presidential advisory committee ACE had limited authority to direct space activities across ministries. Second, it will provide incentives to industry to participate in space projects, increasing innovation and

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[322] Nelly Yañez, “La Agencia Chilena Del Espacio No Tiene Presupuesto 2012, Funcionarios Ni Oficina [The Chilean Space Agency Does Not Have a 2012 Budget, Employees, or Office],” *El Mercurio*, January 15, 2012, sec. National, http://buscador.emol.com//redirect.php?url=http%3A%2F%2Fdiario.elmercurio.com%2Fdetalle%2Findex.asp%3Fid%3D%7B69bebb96-54ef-41ee-9125-893073c30adc%7D.

[323] Roderick Bowen, “Chile Carece de Una Agencia Espacial Y Perú Desarrolla Un Cohete [Chile Lacks a Space Agency and Peru Develops a Rocket],” Guioteca.com, June 20, 2013, http://www.guioteca.com/exploracion-espacial/chile-carece-de-una-agencia-espacial-y-peru-desarrolla-un-cohete/.

[324] Subsecretaría de Telecomunicaciones, “Política Nacional Espacial [National Space Policy]” (Santiago, Chile: Ministerio de Transportes y Telecomunicaciones, 2013), 24, http://www.mtt.cl/wp-content/uploads/2014/02/politica_espacial_31_01_14.pdf.

[325] Ibid., 30–31.

entrepreneurship.[326] Finally, it will boost human resources by increasing opportunities to obtain specialized degrees, training users of space products, and encouraging research (similar to the success Chile enjoys with astronomy research).[327]

On 29 March 2013, Chile established a new space policy committee called the *Consejo de Ministros para el Desarrollo Digital y Espacial* (Council of Ministers for Digital and Space Development).[328] Although Michelle Bachelet took office as President of Chile on 11 March 2014, President Piñera signed this decree into law prior to leaving office. The Council of Ministers met for the first time on 27 August 2014 and again on 29 September 2014.[329] The process of charting a long-term vision for the Chilean space program is progressing slowly. Chile represents a case of a country that has regressed on the Space Technology Ladder.

Since the dissolution of ACE in 2012, the FACh has continued *FASAT-charlie* operations; however, efforts to procure a replacement when its projected operational lifetime ends in 2016 are on hold.[330] The long delay means the FACh will have benefitted entirely from the commercial sale of images from the satellite. According to the *Servicio Aerofotogramétrico* (Aerophotogrametric Service) run by the FACh, *FASAT-charlie* prices range from US$ 0.76 to US$3.50 per square kilometer depending on the image resolution and total image area.[331]

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[326] Ibid., 38.

[327] Ibid., 43, 45.

[328] Subsecretaría de Telecomunicaciones, "Se Crea Consejo de Ministros Desarrollo Digital Y Espacial [Council of Ministers for Digital and Space Development]," April 1, 2014, http://www.subtel.gob.cl/noticias/127-desarrollo-digital/5269-consejo-diigtal-espacial.

[329] Ministerio de Transportes y Telecomunicaciones, "MTT Convoca Al Primer Comité de Ministros Para Definir Política de Desarrollo Espacial [MTT Convenes the First Committe of Ministers to Define Space Development Policy]," August 27, 2014, http://www.mtt.gob.cl/archivos/8047; C. Gonzáles and C. Espinoza, "El Lento Despegue de La Carrera Espacial Chilena [The Slow Take-off of Chile's Space Race]," La Tercera, May 30, 2014, http://www.latercera.com/noticia/tendencias/2014/05/659-580320-9-el-lento-despegue-de-la-carrera-espacial-chilena.shtml.

[330] Carlos González Isla, "La Frágil Política Espacial Chilena [Chile's Fragile Space Policy]," *La Tercera*, La Tercera, September 28, 2014, http://www.latercera.com/noticia/tendencias/2014/09/659-597722-9-la-fragil-politica-espacial-chilena.shtml.

[331] Servicio Aerofotogramétrico, "Servicio Aerofotogramétrico - Productos Y Servicios [Aerophotogrametric Service - Products and Services]," accessed November 29, 2014, http://www.saf.cl/index.php/productos.

F. DISCUSSION

As Arturo Sotomayor observed with Latin America nuclear policy, Latin American space policy is best understood by examining the economic system, the state of civil-military relations, and domestic politics—all directly influence foreign policy.[332] The discussion of Brazil's space program in chapter two introduced three broad themes that frame the activities these programs. First, economic development is the primary motivation of these programs. Second, domestic politics matter most when considering the regional and international orientation of these programs. In addition to these broad themes, several smaller recurring themes emerged from the discussion of these programs. Table 3 summarizes the relevance of these smaller themes to Brazil and the programs discussed in this chapter. This section discusses these smaller recurring themes within the context of the broader themes based on their domestic, regional, and international influence on Latin American space programs.

1. Domestic Factors

All Latin American space programs have at their core the desire to harness space capabilities to further economic development. Each country uses satellite imagery to manage its territory; however, six out of 10 Latin American Space programs have made an effort to acquire some form of Earth-observation capability, either acquiring an indigenous capacity or establishing a collaboration. Half have also acquired at least one GEO communications satellite, while the rest subscribe to international providers. These technologies help overcome the challenging geography of Central and South America, from mountains and jungle, to the vastness of the territories.

[332] Arturo Sotomayor, *US-Latin American Nuclear Relations: From Commitment to Defiance* (Monterey, CA: Naval Postgraduate School, 2012), 4, http://calhoun.nps.edu/public/handle/10945/34346.

Table 3. Summary of recurring domestic, regional, and international themes in Latin American Space Programs

Recurring themes	Argentina	Bolivia	Brazil	Chile	Colombia	Ecuador	Mexico	Peru	Uruguay	Venezuela
Space program during military dictatorship	□		□	□				□[1]	□[4]	
Space program during armed internal conflict					□		□	□		
Space program during armed external conflict	□					□		□		
Military Participation in Space Program	□		□	□		□		□		
Civilian Space Agencies	□	□	□		□		□		□	□
Academia micro-satellite projects	□			□	□	□	□	□	□	
“Pink Tide” Countries	□	□	□	□		□		□	□	□
Sounding rocket program	□		□				□	□		
Collaboration with NASA during 1960s & 1970s			□	□		□	□	□		
Collaboration with China		□	□					□[2]		□
Collaboration with Europe	□			□				□		
Collaboration with Russia	□		□	□	□	□	□	□	□	
Collaboration with U.S. post 1985	□		□	□[3]	□		□	□[3]	□	
Members of UN Conference on Disarmament	□		□	□	□	□	□	□		□

[1] President Fujimori’s regime is counted for this purpose
[2] Through participation in APSCO
[3] Potentially through *SNaP-3*
[4] Military has minimal influence

Domestic politics also lead Latin American countries to pursue different strategies for development. Brazil and Argentina relied heavily on inward-looking ISI policies during military rule.[333] These policies still influence economic policy today, albeit to a lesser degree. Their space programs place a strong emphasis on technology transfer and autonomy. Mexico and Chile, however, more recently have opened their economies to

[333] Emanuel Adler, *The Power of Ideology: The Quest for Technological Autonomy in Argentina and Brazil* (Berkeley, CA: University of California Press, 1987), 105, 153.

foreign investment and have free-trade agreements with the United States.[334] Venezuela, Ecuador and Bolivia, use revenues generated from a booming commodity market to fuel their ideological goals.[335] Bolivia and Venezuela simply purchased space capability with these revenues.

The degree to which civilians direct the action of the space program is an indication of democratic consolidation in these countries. Chile, for example, is working to eliminate some of the prerogatives its military enjoyed before and during the Pinochet regime. Among these prerogatives, the Copper Law (1958) funneled to the military 10 percent revenues generated from copper exports by Chile's state-owned copper company, CODELCO. This gave the Chilean military autonomy from domestic politics that become threatened by the specter of socialism, prompting the overthrow of Allende government in 1973. Since the end of the Pinochet regime in 1989, the Chilean democracy has steadily exerted control over the military.[336] The decision to dissolve ACE and reform it under civilian control is another step in a long process of redefining the role of the military in Chile; however, it appears the military is contesting this decision. In Argentina, the new democracy also drastically reduced the military's involvement in the space program as part of its transition to democracy. In Peru, however, the space agency resides within the ministry of defense, giving the military considerable leverage over its activities. Although this thesis does not classify the Ecuadorian Civilian Space Agency as a national-level agency (see the appendix), the military essentially funds Ecuador's program as a contractor for space activities.

Latin American countries simply do not have the resources to sustain war for very long. Thus, the traditional role of the military of protecting the country from armed external threats has lost its relevance. Latin American militaries in countries with no internal conflict have struggled to redefine their roles. For countries like Argentina,

[334] Peter J. Meyer, *Chile: Political and Economic Conditions and U. S. Relations* (Washington, D.C.:Congressional Research Service, 2014), 9–10; Hakim, "Two Ways to Go Global," 155.

[335] Kurt Weyland, "The Rise of Latin America's Two Lefts: Insights from Rentier State Theory," *Comparative Politics*, 2009, 157–58, http://www.jstor.org/stable/40599207.

[336] Florina Cristiana Matei and Marcos Robledo, "Democratic Civilian Control and Military Effectiveness: Chile," in *The Routledge Handbook of Civil-Military Relations*, ed. Thomas C. Bruneau and Florina Cristiana Matei (New York, NY: Routledge, 2013), 293.

Brazil, Ecuador, and Peru the space program provides a way for the military to stay relevant. After its humiliation in the Falklands/Malvinas War, the Argentine military increased it efforts to develop a ballistic missile as one avenue for maintaining relevance. The Brazilian military maintains its role in the space program and has diversified into peacekeeping operations. After the resolution of the Cenepa War, Ecuador's military competed with the police for internal security work.[337] The Ecuadorian military also operates the national airline, and its heavy involvement in Ecuador's "civilian" space program is further evidence of its efforts to define new missions.

This does not mean that Latin America lacks violence. On the contrary, all Latin American countries struggle with crime to some degree, and some deal with internal armed conflict. Countries with ongoing internal conflicts like Colombia, Mexico, and Peru also gain from space. In Mexico, the police force is fragmented across federal, state, and municipal lines, giving rise to roughly 2,000 different police forces, which do not communicate well with one another.[338] By placing government communications on a common network, Mexsat-*1* and *2* can potentially unify the actions of its police forces and the military in the struggle against organized crime. Peru's emphasis on Earth-observation gives the military tools in its effort to combat illicit coca cultivation and the remnants of the *Sendero Luminoso*. While Colombia has not chosen to invest in its own Earth-observing assets, it benefits from international space assets in its internal struggle against the insurgent group *Fuerzas Armadas Revolucionarios de Colombia* (Revolutionary Armed Forces of Colombia, FARC) and drug trafficking organizations.

As Latin American democracies assert more control over the military, the military must compete for funding with another type of internal threat: "widening poverty, unemployment, declining social welfare services, and so on."[339] This directly impacts space programs with direct military participation, as in Argentina, Brazil, Chile, Ecuador,

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337 Maiah Jaskoski, *Military Politics and Democracy in the Andes* (Baltimore, MD: Johns Hopkins University Press, 2013), 149.

338 Luis Astorga, "México: Organized Crime Politics and Insecurity," in *Traditional Organized Crime in the Modern World*, ed. Dina Siegel and Henk van de Bunt (New York, NY: Springer, 2012), 155.

339 David S. Pion-Berlin, "Political Management of the Military in Latin America," *Military Review* 85, no. 1 (February 2005): 25.

and Peru. Even the civilian side of these space programs suffers from the same lack of electoral incentives that lead politicians to disregard military policy.

Finally, for Bolivia and Venezuela, space development is also tied to bolstering support for populist leaders. As mentioned earlier, President Chávez used *VENESAT-1* to expand the reach of his Bolivarian revolution to rural communities in Venezuela and even spread his message beyond Venezuela's borders. President Morales recently touted that subscription costs for satellite television and some Internet service plans have been cut in half after the *TKSAT-1* came into service, bolstering his populist image.[340] The satellite purchases also express these regimes' desires to minimize U.S. influence by reaching out to China, an ideologically similar nation.

2. Regional and International Factors

While rare, interstate conflict has occurred in Latin America. Participating in interstate conflict would reasonably impart realist motives for developing space capabilities. While the military strongly influences Peru's space program, Peru's space activities appear to be directed at detecting illicit activities within its borders and only involve Ecuador to the extent these illicit activities cross the border. Ecuador and Peru enjoy positive bilateral relations at present.[341] In contrast, Argentina's defeat in the Falklands/Malvinas War intensified the military's efforts to acquire ballistic missiles. As discussed in this chapter, President Menem's reforms quashed the geopolitical motivation of the space program.

Regional cooperation in Latin America in space has been hindered first by the initial lack of expertise, and, second, by a lack of leadership. Early in the space age, Argentina and Brazil had the greatest opportunity to collaborate due to the similarity in their technological level and geographic proximity. During the period of military

[340] Peter B. de Selding, "Morales Says Bolivians Saving a Bundle Thanks to Nation's 1st Telecom Satellite," Space News, accessed October 24, 2014, http://www.spacenews.com/article/satellite-telecom/40102morales-says-bolivians-saving-a-bundle-thanks-to-nation%E2%80%99s-1st-telecom.

[341] Andina, "Lo Mejor Entre Perú Y Ecuador Está Por Comenzar, Afirma Presidente Rafael Correa [The Best between Peru and Ecuador Is Just Beginning, Affirms President Rafael Correa]," June 10, 2010, http://www.andina.com.pe/agencia/noticia-lo-mejor-entre-peru-y-ecuador-esta-comenzar-afirma-presidente-rafael-correa-ampliacion-300582.aspx.

governance and rivalry, however, both looked to acquire technology from more advanced space-faring nations. As the programs of Argentina and Brazil have matured, the opportunities to lead at the regional level have increased. Both Argentina and Brazil have ties with other regional space programs. As mentioned in chapter two, the rise of the New Left has led to the creation of new regional multilateral organizations. Thus, ALAS makes sense now, especially since opportunities to collaborate outside the region have decreased.

International forces can aid and inhibit space programs. Brazil, Chile, Ecuador, Mexico, and Peru all benefitted from cooperation with NASA in the infancy of the space age on satellite tracking, space research, and sounding rocket projects. While Chile remained a center for international cooperation in astronomy, cooperation with the U.S. on other space projects diminished across Latin America for several reasons. For Argentina and Brazil, the dual nuclear and sounding rocket programs sparked fears of an arms race, triggering a response from the international community. U.S. intervention to prevent the transfer of missile and nuclear technology ran afoul of two cherished norms in Latin America—sovereignty and equality between states.[342] Furthermore, many military regimes resorted to isolationism to avoid censure for human rights violations.[343] In the Andean nations, U.S. collaborations tend to focus more on combating drug trafficking organizations and insurgency.[344] Since the transition to democracy, Argentina enjoyed the most successful collaboration with the Unites States; however, this collaboration is in danger of ending under the Kirchner regime.

The rise of the New Left has also prompted Latin American countries to diversify their economic interests. In 2005, the United States consumed 36 percent of all exports from the region.[345] By 2012, this share had shrunk to 25 percent, while Asia's share

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[342] Kacowicz, *The Impact of Norms*, 59.

[343] Sotomayor Velázquez, "Different Paths and Divergent Policies in the UN Security System," 367.

[344] John F. Kelly, "Posture Statement of General John F. Kelly, United States Marine Corps, Commander, United States Southern Command Before the 113th Congress," U.S. Southern Command, March 13, 2014, http://www.southcom.mil/newsroom/Pages/2014-Posture-Statement-to-Congress.aspx

[345] World Trade Organization, World and Regional Export Profiles 2012, accessed 26 February 2014, http://www.wto.org/english/res_e/statis_e/world_region_export_12_e.pdf.

increased from 13 percent to 23 percent in the same period.[346] This is seen in their outreach in space as well. Latin American space programs favor contracts and collaborations that result in the transfer of technology and the development of human capital. While U.S. universities play an active role in educating space professionals worldwide, export control laws limit the scope of potential projects available to U.S. companies and government agencies. Even when Latin American Universities have succeeded in constructing a small satellite, they almost exclusively rely on Russia to launch them into space. Thus, the outreach to China, Europe, and Russia is not solely an expression of anti-U.S. sentiment—it is a matter of necessity to gain access to more advanced technology, Furthermore, China's "no political strings" policy respects Latin American sovereignty.[347]

Finally, while not all Latin American nations are members of the CD, all Latin American nations approve the yearly UN PAROS resolution. The vote, however, is largely symbolic since the CD is deadlocked.[348] Given the reputation of Latin America as a norms entrepreneur, the time may be right for the region to adopt a "Treaty of Tlatelolco" for space cooperation. Although the proposed ALAS does not list this as one of its aims, the alliance could lead to a clearer definition of these norms than the great powers are willing to propose.

G. CONCLUSION

This chapter reviewed the space programs of Argentina, Chile, Mexico, Peru, and Venezuela, giving enough historical detail to assess each program's progress along the Space Technology Ladder and identifying the major domestic, regional, and international factors in each. Table 4 summarizes the progress of each program on the Space Technology Ladder.

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346 Ibid.

347 Riordan Roett and Guadalupe Paz, "Introduction: Assessing the Implications of China's Growing Presence in the Western Hemisphere," in *China's Expansion into the Western Hemisphere: Implications for Latin America and the United States*, ed. Riordan Roett and Guadalupe Paz (Washington, D.C: Brookings Institution Press, 2008), 3.

348 Moltz, *Crowded Orbits*, 157.

Table 4. Summary of Space Technology Ladder Progress

Level	Argentina	Bolivia	Brazil	Chile	Colombia	Ecuador	Mexico	Peru	Uruguay	Venezuela
13			□							
12	□		□							
11	▯									
10										
9										
8	▯	▯	▯				▯			▯
7	▯		▯							
6	▯		▯							
5					▯	▯	▯	▯	▯	
4	▯		▯							□
3	▯			▯				□		▯
2	▯	▯	▯	□			▯	▯		▯
1			▯	▯	▯		▯		▯	▯

▯ - complete; □ - projected within 5 years; ▯ - micro-satellite

Argentina and Brazil lead Latin America in space development. The countries are also closely matched in capability, with Argentina ahead in GEO satellite capability and Brazil further ahead with launcher capability. Beyond Argentina and Brazil, space capabilities drop off quickly. Other programs are focused on specific development goals, like communication and Earth-observing satellites. All programs are working to train space professionals, even including training as part of procurement contracts. Many Latin America universities are also training engineers through small satellite development projects. Chile is awaiting the launch of their micro-satellite. All the rest succeeded in securing flights launching from Russian spaceports.

The experiences of these programs also validate the developmental focus of the programs; the primacy of domestic politics, including civil-military relations; and, the positive and negative aspects of international influence. The final chapter of this thesis examines the implications for U.S. space policy in the region, specifically addressing what can be done to increase engagement on space projects.

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IV. CONCLUSION

If Keohane and Nye are correct and interdependence among nations eventually overcomes geopolitics and fosters peaceful relations on Earth, then the same complex interdependence in space could also solve many of the space security issues faced today. The United States has enjoyed an unparalleled freedom to operate independently in space. Not surprisingly, it is reluctant to give up those freedoms without a clear guarantee of security. The National Space Policy released by the Obama administration in 2010 signaled a change toward a more international approach to space security; however, this vision faces many challenges domestically and internationally.[349] The domestic political deadlock in the U.S. Senate makes it unlikely that the Unites States will enter into any binding treaties governing the norms of space. Internationally, the Unites States and Israel oppose the Chinese-Russian PPWT proposal since it lacks a means to verify compliance.[350] As Moltz argues, attempting to retain complete independence is not a sustainable strategy in space any more than it is on Earth.[351] The United States must engage the international community on this issue more effectively.

The United States now faces the reality of 10 space programs in Latin America, with Argentina and Brazil nearing launch capability. One troubling trend that emerged from the previous chapters is the limited engagement that the United States currently has with Latin American space programs. While collaborations with China, Russia, and Europe have been an overall positive influence in Latin American space programs, the United States should also be strengthening partnerships through peaceful cooperation in science and technology. Many Latin American militaries still participate in space activities, opening a military-to-military avenue of collaboration. Also, for the past two decades stringent U.S. export control regulations have encouraged foreign countries to avoid the United States as an international collaborator. These restrictions along with the

[349] The White House, "National Space Policy of the United States of America" June 28, 21010, 6–7, http://www.whitehouse.gov/sites/default/files/national_space_policy_6-28-10.pdf.

[350] Moltz, *Crowded Orbits*, 157.

[351] Ibid., 154, 181.

rise of the New Left have driven the trend of Chinese and European outreach to Latin America in space. The stiff fines for non-compliance discourage many U.S. citizens and companies from dealing with the export control process entirely. This has limited the scope of educational opportunities at U.S. universities as Latin American countries seek training for their space professionals. The recent revision of U.S. export control laws promises to remove many of these barriers. This last chapter examines how the Unites States can increase its engagement in Latin American space programs in the military, commercial, and civilian realms with the goal of increasing space security through interdependence.

A. MILITARY COOPERATION

As discussed earlier, the period of military rule limited the opportunities to collaborate in space. Not all Latin American countries had space programs during this period, and the ones that did isolated themselves due to their poor human rights records. Since the return to democracy, Latin American militaries have largely been stripped of their leadership roles in their national space programs, albeit civilian control is tenuous in some cases. USSOUTHCOM already collaborates with Latin American on a broad range of security issues, including combating drug trafficking organizations, humanitarian assistance, and peacekeeping.[352] The rise of the New Left has hampered military-to-military cooperation in Argentina and Venezuela; however, the United States Armed Forces maintains close ties with other militaries of New Left administrations. For example, even though the Correa administration refused to renew the lease on Manta Air Base in Ecuador, Ecuador still receives assistance in removing anti-personnel mines and the Ecuadorian Navy participates in the UNITAS PAC naval exercise. Thus, even when diplomatic relationships are strained, the military can provide an avenue for cooperation.

USSOUTHCOM's outreach with the *SNaP-3* satellite is a step in the right direction. As seen previously in Table 3, small satellite development is a common stepping stone to training space professionals for larger projects. The satellite has capabilities similar to Brazil's data collecting satellites. The *SNaP-3* system can

[352] Kelly, *Posture Statement of General John F. Kelly, United States Marine Corps*, 26–41.

communicate with ground sensors and can also relay data to military units beyond the line of sight.[353] All of these capacities are useful in Latin America's rugged terrain. Peru, Brazil, and Chile have expressed interest in participating with USSOUTHCOM to test *SNaP-3* capabilities in the field once new satellites are launched by the United States in 2015.

The military is also positioned well to assist Latin American countries train space professionals. To foster these educational opportunities, USSOUTHCOM, in conjunction with the Naval Postgraduate School and the Air Force Institute of Technology, should reach out to sponsor foreign officers to receive graduate instruction in space systems engineering and remote sensing. Both institutions have programs that would meet the needs of these students. The relaxation of export controls may provide opportunities to expand foreign participation in these degree programs. USSOUTHCOM, in conjunction with the Air Force Office of Scientific Research, the Office of Naval Research, and the Army Research, should also coordinate faculty exchanges with Latin American aerospace programs. Prime candidate institutions would include Brazil's ITA and Argentina's IIAE.

The classified nature of U.S. space operations complicates military operational exchanges; however, to the extent possible, officer exchanges could enhance the professionalism of Latin American space operators. These exchanges could take on several forms. Latin American space launch officers could be invited to observe unclassified launch operations and learn launch safety procedures. To aid information sharing, it may be possible to establish Latin American liaison elements with the Joint Space Operations Center. This could be the beginning of establishing partnerships to enhance space situational awareness (SSA) networks in Central and South America. Chile, for example, has many locations suitable for optical monitoring of the space environment.

The United States also has an interest in building alliances with Latin American space programs to help support its vision of international space security and governance.

[353] Kenneth Stewart, "Naval Postgraduate School - Southcom Turns to NPS to Evaluate CubeSats for Communications Support," Naval Postgraduate School, January 22, 2104, http://www.nps.edu/About/News/Southcom-Turns-to-NPS-to-Evaluate-CubeSats-for-Communications-Support.html.

Brazil is an active participant in space diplomacy at the CD. Increased cooperation with Brazil on space projects will facilitate Brazil-U.S. dialogue on security issues including the CoC and PPWT. Brazil and other Latin American nations should also be encouraged to define the norms for peaceful space cooperation among themselves as they pursue ALAS. This could lead to a “Treaty of Tlatelolco” for space norms. Strengthening ties with Brazil and Mexico will also help maintain Central and South America as a zone of peace.

B. COMMERCIAL COOPERATION

The United States government has long relied on a cumbersome system to prevent the export of sensitive military or dual-use items or services. The Arms Export Control Act (AECA) and the Export Administration Act of 1979 form the legal framework for the system. The AECA gives the President of the United States the authority to restrict the export of items and services related to defense. The State Department implements this authority via the International Traffic in Arms Regulations (ITAR). To accomplish this, the State Department maintains the United States Munitions List (USML), which identifies all military items and services that cannot be exported. The Export Administration Act of 1979 tasks the Department of Commerce with controlling the export of sensitive dual-use technologies. The Department of Commerce implements this authority through the Export Administration Regulations, which, in turn, creates, the Commerce Control List (CCL) that identifies restricted dual-use technologies. The CCL also implements the restrictions stipulated by several nonproliferation regimes, including the MTCR.[354]

The U.S. space industry has been harmed by these regulations. As the military relied more on commercial technology for acquisitions, the USML and the CCL began to overlap, creating ambiguities.[355] Furthermore, in 1999, the U.S. government moved all satellites and components to USML Category 15 (Spacecraft Systems and Related

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[354] Department of State, “Overview of U.S. Export Control System,” March 8, 2011, http://www.state.gov/strategictrade/overview/.

[355] Export.gov, “Controlled Items on a Single List,” July 3, 2014, http://export.gov/ecr/eg_main_027617.asp.

Articles) after U.S. companies Loral and Hughes Space & Communications assisted China in discovering the root cause of the booster failure resulted in the loss of *Intelsat 708*.[356] The more restrictive USML inhibited the ability of U.S. satellite manufacturers to compete in the world market with the CGWIC and Airbus Group that both make ITAR-free systems.[357] From 1995 to 2005, the U.S. market share of satellite exports dropped from 73 percent to 25 percent.[358] A report released by the Department of Commerce estimates the U.S. space industry suffered between US$988 million and US$2 billion in lost sales opportunities from 2009 to 2012 (compiled from the data supplied by 995 respondents to the study).[359]

The impact on Latin America is difficult to assess. Export controls did not prevent Boeing from collaborating with Mexico on the *Mexsat* satellite series, nor did they prevent Argentina from collaborating with NASA on the *SAC* satellite series. While U.S. export controls contributed to the rise of Chinese space cooperation in the region, domestic political considerations likely eliminated U.S. companies from serious consideration. U.S. companies likely had no chance to compete with China for the *VENESAT-1* contract given the political landscape in Venezuela at the time. Clearly, export controls limit the scope of potential projects and require both a U.S. and foreign entity willing to comply with the costly regulations.

Additionally, many of the impacts of export control are hard to measure. In the absence of U.S. suppliers, Brazil, Peru and others had no other recourse but to develop their own industrial base or import satellites from other countries. Many U.S. universities refuse to participate in ITAR-restricted projects as they limit the participation of their foreign students in educational opportunities and restrict the ability of faculty members to

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[356] Bureau of Industry and Security, *U.S. Space Industry "Deep Dive" Assessment: Impact of U.S. Export Controls on the Space Industrial Base* (Washington, D.C.: Department of Commerce, 2014), 42.

[357] OECD, *The Space Economy at a Glance 2014* (Paris, France: OECD Publishing, 2014), 29, http://public.eblib.com/choice/PublicFullRecord.aspx?p=1870780.

[358] Morgan Dwyer et al., "The Global Impact of ITAR on the For-Profit and Non-Profit Space Communities," in *Proceedings of the 25th Symposium on Space Policy, Regulations and Economics* (Naples, Italy: International Astronautical Federation, 2012), 9, http://dspace.mit.edu/handle/1721.1/80837.

[359] Bureau of Industry and Security, *U.S. Space Industry "Deep Dive" Assessment*, 28.

disseminate their research, especially non-U.S. faculty members.[360] Thus, export controls limit the U.S. ability to train and otherwise cooperate with Latin American space professionals.

In 2009, the Obama administration announced the Export Control Reform Initiative. Part of this reform included the revision of USML Category 15. Now, all satellites with a specific military or intelligence mission remain in the USML, but the following have been moved to the CCL:

> Communications satellites that do not contain classified components; remote sensing satellites with performance parameters below certain thresholds; and, systems, subsystems, parts, and components associated with these satellites and with performance parameters below certain thresholds specified for items remaining on the USML.[361]

These new rules went into effect on 10 November 2014. Reaction to the new rules has been mixed. On one hand, the CCL and USML retain separate lists and significant restrictions still remain.[362] On the other hand, the industry is cautiously optimistic about regaining some of the world market share of satellites.[363] The potential benefit to Latin America is also mixed. According to the Commerce department report, Brazil and Mexico are among the top 20 destinations for U.S. space-related exports; however, neither is eligible for the Strategic Trade Authorization license exception, which eliminates much of the regulatory overhead on U.S. companies.[364] As a way forward, the U.S. satellite industry should consider adopting the Chinese model of coordinating graduate education in space systems in conjunction with large satellite purchases. Within

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[360] Dwyer et al., "The Global Impact of ITAR," 13–15.

[361] Reid Whitten, "ECR Episode XI: Rewriting the Guide to the Galaxy – Satellites Passed to Commerce Control," The National Law Review, accessed November 10, 2014, http://www.natlawreview.com/article/ecr-episode-xi-rewriting-guide-to-galaxy-satellites-passed-to-commerce-control.

[362] Jeff Foust, "Despite Reforms, U.S. Export Control Rules Remain Complicated," Space News, November 1, 2014, http://www.spacenews.com/article/civil-space/42430despite-reforms-us-export-control-rules-remain-complicated.

[363] Caleb Henry, "US State Department Finalizes Satellite Export Reform," Via Satellite, November 13, 2014, http://www.satellitetoday.com/regional/2014/11/13/us-state-department-finalizes-satellite-export-reform/.

[364] Bureau of Industry and Security, *U.S. Space Industry "Deep Dive" Assessment*, 50–51.

the limits of the remaining ITAR restrictions, U.S. corporations should engage Latin American countries on Earth-observing systems, which are in demand. U.S. space launch providers should also consider investing in Brazil's CLA. The United States could encourage Brazil to consider leasing other sections of the CLA for foreign direct investment in GEO launch capability, as it has with ACS. Brazilian-SpaceX Corporation collaboration could be profitable.

Micro-satellites are becoming popular in Latin America due to their low cost and rapid deployability. Universities use small satellite projects to educate aerospace engineers. Once built, these satellites need a ride into space. In 2011, the Federal Aviation Administration reported on an effort by the U.S. Army Space and Missile Defense Command (USASMDC) to develop a launcher capable of lofting a 10-kilogram payload into LEO for approximately US$1 million.[365] This effort is similar to the Microsatellite Launch Vehicle currently under joint development by Brazil and Germany. Although it appears that the USASMDC effort has stalled, this capability could serve a niche market worldwide if developed.

C. CIVILIAN COOPERATION

As this thesis has demonstrated, formal government outreach between national space agencies and informal outreach via university-to-university collaborations and space interest groups (e.g. AMSAT) each play an important role in Latin America. Formal outreach to Brazil in civil space activity should be the keystone to a new U.S. Latin American space policy. Within the next five years Brazil should achieve launch capability and will be a leader among other South American space programs. The United States should encourage AEB-NASA collaboration on space projects, including reinvigorating the ISS collaboration; however, reviving Brazilian cooperation cannot be approached as a single issue. Diplomatically, Brazil's goal is to secure a permanent seat on the UNSC. In space, Brazil wants to make the CLA a profitable launch center. The

[365] Federal Aviation Administration, *2011 U.S. Commercial Space Transportation Developments and Concepts: Vehicles, Technologies, and Spaceports* (Washington, D.C.: Federal Aviation Administration, 2011), 20, https://www.faa.gov/about/office_org/headquarters_offices/ast/reports_studies/developments_concepts/.

two goals are linked. The United States must approach any invitation to participate in the ISS with this in mind. The CLA rests at the nexus of military, commercial, and civilian cooperation in space for Brazil. While the U.S. does not currently support Brazil in its bid for a permanent UNSC seat, the U.S. should look at ways to use the CLA for scientific research, even to the point of assisting with the VLS-1 vehicle. The VLS-1 poses no commercial threat to U.S. space launch providers and would allow Brazil to serve the growing small satellite market. Cooperation with Brazil on the VLS-1 may help thaw Argentine-U.S. relations enough to allow collaboration on the Tronador II. Close integration with these programs would allow the United States to satisfy any missile proliferation concerns.

Collaboration on projects at the CLA would help mend past Brazil-U.S. tensions, and Brazil's desire for permanent seat on the UNSC could motivate it to renew its commitment to the ISS. Collaboration should involve personnel exchanges with NASA, including new Brazilian astronauts. Unlike the previous attempt at ISS collaboration, the projects should be matched with Brazilian industrial capability. Of course, prior to any ISS collaboration, Brazil may opt for a joint satellite mission first. With the relaxed export control laws, the space of potential projects is broader. Eventually, the collaboration could include a joint robotic exploration mission with other Latin American partners as well.

Opportunities for formal collaboration with the other major space programs in Latin America vary. Venezuela's ABAE is a poor prospect for collaboration in space at present due to the anti-American posture of the current administration and a deepening economic crisis. Likewise, options for collaboration in Argentina are limited; however, NASA should maintain its ties to CONAE through the *SAC-D Aquarius* mission. NASA is already reaching out to Mexico's AEM. NASA had contact with Chile's ACE while it existed. In 2010, ACE contacted NASA to assist the team working to recover the 33

trapped miners.[366] Once Chile reestablishes its space program, NASA should reestablish contact.

Opportunities to collaborate formally with Latin America's minor space programs are limited. This thesis classifies the programs of Bolivia, Colombia, Ecuador, and Uruguay as minor space program due to the limited scope of their activities; however, they should not be ignored. Like Argentina and Venezuela, civilian collaboration with Bolivia's ABE and Ecuador's EXA may be problematic at present. For now, ABE's sole focus is operating *TKSAT*-1. The legal mandate that established Ecuador's EXA will expire in 2019, leaving an uncertain window of opportunity to collaborate even if domestic politics were favorable. Colombia has decided to hold off on purchasing satellites at present, focusing instead on leveraging foreign space capability while it attempts to end its internal conflict. Uruguay's program focuses on space policy issues, making it a norm entrepreneur in Latin America. These programs would benefit more from the regional integration that ALAS promises to provide as well as informal outreach outside Latin America.

The growing number of small satellite projects in Latin America illustrates the importance of informal outreach in space. Many Latin American universities have groups working on small satellite projects that could benefit from increased ties with U.S. universities. California Polytechnic State University, for example, collaborated with Colombia's *Universidad Sergio Arboleda* to perform the flight qualification testing on its small satellite, *Libertad-1*. The burden of establishing informal connections falls to the universities themselves; however, national space agencies can do more to facilitate these efforts. The Department of Commerce report cited that many businesses do not understand export control regulations and are deterred by the complexity of the laws.[367] The same ambiguities threaten academic collaboration as well.[368] NASA and the Department of State could facilitate informal outreach in space by providing

[366] National Aeronautics and Space Administration, "NESC Provides Support to Trapped Chilean Miners," February 15, 2011, http://www.nasa.gov/offices/nesc/home/Feature_Chilean_Miner_Rescue_Support.html.

[367] Bureau of Industry and Security, *U.S. Space Industry "Deep Dive" Assessment*, 53–54.

[368] Dwyer et al., "The Global Impact of ITAR," 11–12.

unambiguous guidance on the scope of space projects that are uninhibited by the revised ITAR restrictions. NASA could also help identify national or commercial launch opportunities that would permit small satellite "stowaways." This is a difficulty that even American projects like *SNaP-3* face. To date, the most common solution to this problem in Latin America is securing a ride aboard a Russian Dnepr rocket.

Whether formal or informal, outreach to these countries should focus on what they need most—increased education and training opportunities to enlarge the pool of qualified space professionals. NASA has an international internship program for undergraduate and graduate students; however, Mexico is the only Latin American country with an agreement in place to participate.[369] This avenue for collaboration should be extended to all Latin American space programs. Unambiguous ITAR guidance could also increase the realm of possibilities in informal outreach as well.

D. CONCLUSION

Latin America will develop space capabilities and the United States will have to choose the level of interaction it desires with these regional space programs. The current policy largely ignores them, which could lead to security dilemmas in the future. The best way to ensure smooth relations in the future is to collaborate now. This thesis has demonstrated that the *raison d'être* of Latin American space programs is to promote economic development. Coupled with Latin American norms of sovereignty and peaceful resolution of disputes, these space programs also promote a broader notion of national security than military power alone. To the extent that these programs exhibited geopolitical competition in the past, transitions to democracy have tempered that tendency. Understanding the domestic politics of each country is the key to understanding the regional and international orientation of the program. These motivations vary based on the current ideology in power and the chosen strategy for development. International collaboration has been a boon to these fledgling programs, but their unstable funding prevents them from gaining all they can from these collaborations.

[369] National Aeronautics and Space Administration, "Internship Information - NASA OEID LaunchPad," November 25, 2014, https://intern.nasa.gov/non-us-opportunities/index.html.

While international nonproliferation regimes have hindered the progress of Argentina and Brazil, both are ready to take a leadership role among other Latin American space programs. The explosion of space activity in the developing world is exciting. With revised export control regulations, a greater emphasis on training and civilian engagement, and a smart use of military-to-military programs, the United States could pursue greater engagement in the region. The United States should not dismiss the opportunity to reach out to our space-faring neighbors in Latin America.

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APPENDIX. MINOR LATIN AMERICAN SPACE PROGRAMS

This appendix contains descriptive information about the smaller space programs in Latin America. Granted, this is a subjective distinction. The decision to classify the space programs of Bolivia, Colombia, Ecuador, and Colombia as minor space programs is based primarily on the limited scope of the activities of their space agencies.

A. BOLIVIA

Bolivia is Latin America's newest entry into space. On 10 February 2010, President Evo Morales signed the decree creating the *Agencia Boliviano Espacial* (Bolivian Space Agency, ABE).[370] The mission statement of the ABE details the very specific purpose for which it was created: "Manage and execute the implementation of the Tupac Katari Satellite Communications Project and other State space projects, such as assimilate, develop, and apply space knowledge to benefit all Bolivians."[371] ABE started with a budget of US$1.0 million.[372] In August of that same year, Bolivia contracted with CGWIC to build Bolivia's first telecommunications satellite *TKSAT-1* (Túpac Katari Satellite). The name of the satellite is a tip-off to Bolivia's purpose for pursuing the project. In 1780, Túpac Katari led a revolt against the Spanish in what is now Bolivia. The project aims not only to end Bolivia's dependence on foreign communications satellites but also to extend telecommunication coverage to the entire country. The rugged terrain of Bolivia, like other Andean nations, drives up the cost of ground telecommunications infrastructure, resulting in the isolation of rural communities. An estimated 3.3 million Bolivians have no access to telecommunications at all.[373]

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[370] Agencia Efe, "Aprueban La Creación de La Agencia Espacial Para Gestionar Proyecto de Satélite Propio [The Creation of a Space Agency Was Approved to Manage In-House Satellite Project]," *Los Tiempos*, February 10, 2010, http://www.lostiempos.com/diario/actualidad/nacional/20100210/aprueban-la-creacion-de-la-agencia-espacial-para-gestionar-proyecto-de_57315_102592.html.

[371] Agencia Boliviana Espacial, "Misión Y Visión [Mission and Vision]," accessed October 24, 2014, http://www.abe.bo/misionvision.html.

[372] Rory Carroll, "Bolivia to Launch Satellite into Space," The Guardian, February 12, 2010, http://www.theguardian.com/world/2010/feb/12/bolivia-launch-satellite-space.

[373] Peter B. de Selding, "China Launches Bolivia's First Telecom Satellite," Space News, December 23, 2014, http://www.spacenews.com/article/launch-report/38800china-launches-bolivia%E2%80%99s-first-telecom-satellite.

Bolivia contracted with CGWIC for a package deal that included the standard Chinese DFH-4 platform, launch services, and financing. The total project cost US$295.4 million, with US$44.3 million funded by the Bolivian treasury and the rest financed by the China Development Bank over 15 years.[374] According to ABE, Bolivian companies paid upwards of US$10 million per year for bandwidth on foreign satellites.[375] Given the estimated lifetime of 15 years for the satellite, it is unlikely that the Bolivian government will break even on the investment unless the customer base substantially increases. China successfully launched *TKSAT-1* into GEO orbit on 21 December 2013. In April of 2014, President Morales claimed that satellite television subscriptions rates have dropped by 50 percent, and Internet rates have dropped from 20 percent for low-bandwidth plans to 50 percent for high-bandwidth plans.

Notwithstanding President Morales's anti-US rhetoric, Bolivia's space program again illustrates the primary inward focus of these programs. Improving the quality of life for Bolivians helps reduce the instability that exists within Bolivia's borders. Improving telecommunications forges a stronger link between disparate rural communities and the government. The international orientation of Bolivia's space program is strongly influenced by Latin American norms. At first glance, the fact that ABE is exploring opportunities to cooperate with Argentina's CONAE would indicate a realist orientation, given the historic rivalry between Argentina and Chile.[376] In April of 2013, Bolivia filed a case against Chile in the International Court of Justice (ICJ) to require Chile to negotiate Bolivian access to the Pacific Ocean, which Bolivia lost as a result of the War of the Pacific (1879-83).[377] Peru's ICJ victory in January of 2014 against Chile in their maritime dispute likely encourages Bolivia. Bolivia is not currently pursuing military options to accomplish the same aim. Bolivia, however, also had a favorable response to Brazil's proposal for ALAS. If formed, ALAS would bring Bolivia into cooperation with

374 Ibid.

375 Agencia Efe, "Bolivia anuncia la creación de una agencia espacial [Bolivia Announces the Creation of a Space Agency]," *El País*, October 6, 2009, http://sociedad.elpais.com/sociedad/2009/10/06/actualidad/1254780011_850215.html.

376 Comisión Nacional de Actividades Espaciales, "Visita Oficial."

377 International Court of Justice, "Contentious Cases," accessed October 24, 2014, http://www.icj-cij.org/docket/index.php?p1=3&p2=3&case=153.

Chile, which also responded favorably to the idea. Other foreign policy choices give further support to Bolivia's normative orientation. Bolivia has taken a strong stance against U.S. counternarcotic influence within its borders, citing violations of its sovereignty.[378] Coca cultivation is a source of income for Bolivia's rural population. This reinforces the assertion that Bolivia is acting to improve the economic conditions of its citizens, which Bolivian history demonstrates is essential to staying in power.

B. COLOMBIA

Colombia's 50-year struggle against the FARC, as well as the fights against drug trafficking, delayed Colombia's entry into space. During the presidency of Álvaro Uribe, Colombia created a vision for a peaceful more equitable country by the year 2019, marking the 200th year of Colombian independence. The vision was published in 2005 as *Visión Colombia II Centenario: 2019*. Although this plan focused on social issues, President Uribe signed Decree 2442 in 2006 creating the *Commisión Colombiano del Espacio* (Colombian Space Commission, CCE) in 2006. The first paragraph of this decree acknowledges the diverse roles that space can play in achieving Colombia's development goals.[379]

The Vice-President of Colombia heads the CCE and is joined by the head of various government ministries, with representation from the *Fuerza Aérea Colombiana* (Colombian Air Force, FAC), civil aviation, and other technical institutes. These representatives serve as voting members on the board. In addition, the board allows representatives from industry and academia to participate as non-voting members. At the same time, the decree established the *Comité Técnico de Asuntos Espaciales* (Space Technical Committee), which is responsible for making project proposals. This committee is composed of individuals designated by the voting members of the CCE.[380] The activities of the CCE are focused on seven areas: telecommunications, satellite

[378] "Bolivia Halts U.S. Anti-Drugs Work," BBC, November 1, 2008, http://news.bbc.co.uk/2/hi/americas/7704528.stm.

[379] Ministerio de Relaciones Exteriores, "Decreto 2442 de 2006 [Decree 2442 of 2006]," July 21, 2006, https://www.cancilleria.gov.co/sites/default/files/Normograma/docs/decreto_2442_2006.htm.

[380] Ibid.

navigation, Earth observation; astronautics, astronomy, and space medicine; knowledge and research management; political and legal aspects of space; and, infrastructure for disseminating space data.[381] Notably absent are any plans to develop space launch capabilities.

The first success of Colombia in space cannot be entirely attributed to the CCE. In March of 2006, students at *Universidad Sergio Arboleda* completed the preliminary design of *Libertad*-1, using a CubeSat design. The project started as a teaching project, but soon had the support of the FAC, Colombian civil aviation, and industry. The California Polytechnic State University performed the acceptance tests, and the satellite successfully launched aboard a Dnepr rocket from the Baikonur Cosmodrome on 17 April 2007.[382] The radio beacon on the satellite functioned normally during its 34-day mission.[383]

Progress toward other satellites has been very slow. In 2008, the CCE proposed buying two satellites, one GEO telecommunications satellite and one Earth-observation satellite. Colombian companies currently contract with INTELSAT to provide satellite telecommunications services.[384] In 2009, Colombia released a call for bids to build *Satélite Colombia* (Colombian Satellite, or *SatCol*). The only company that placed a bid, the Reshetnev Company from Russia, failed to meet the requirements.[385] In 2010, Colombia also rejected a proposal from the CGWIC. Colombia abandoned efforts to

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[381] Comisión Colombiano del Espacio, "Visión Colombia II Centenario: Aprovechar El Potencial Del Espacio Extraterrestre Para Contribuir Al Desarrollo Sostenible Y La Competividad Del País [Centenary Vision Colombia II: Taking Advantage of Outer Space to Contribute to Sustainable Development and Competitiveness of the Country]," accessed October 30, 2014, https://www.cce.gov.co:8543/alfrescocce-5.1.1.1/d/d/workspace/SpacesStore/c9baa5d1-42e6-11e2-8872-11f7c848c718/Visión%202019%20Consolidado%20ver%206%20definitivo.pdf.

[382] Universidad Sergio Arboleda, "Libertad-1," accessed October 30, 2014, http://www.usergioarboleda.edu.co/proyecto_espacial/docs/english_libertad.pdf; International Space Company Kosmotras, "Dnepr Successfully Returns to Flight," April 17, 2007, http://www.kosmotras.ru/en/news/23/.

[383] Harding, *Space Policy in Developing Countries*, 162.

[384] Intelsat, "Gilat Utilizes Intelsat Satellite Services to Deliver Broadband Connectivity to Schools and Communities in Rural Colombia," June 23, 2014, http://www.intelsat.com/news/gilat-utilizes-intelsat-satellite-services-to-deliver-broadband-connectivity-to-schools-and-communities-in-rural-colombia/.

[385] Ricardo Revelo C., "Colombia Sin Satélite: ¿un Paso Atrás Del País En Su Carrera Espacial? [Colombia without A Satellite: A Step Back for the Country in Its Space Race?]," *El Tiempo*, September 16, 2014, http://www.eltiempo.com/archivo/documento/CMS-14539258.

procure *SatCol* in 2011 in favor of a project to modernize Colombia's telecommunications with fiber optics.[386]

The FAC's efforts to procure *Satélite de Observación de la Tierra Colombiano* (Colombian Earth-observing Satellite, or *SotCol*) have also hit similar snags. In September of 2014, the current Vice-President of Colombia, Germán Vargas Lleras, announced that Colombia no longer has plans to procure *SotCol*. According to government estimates, Colombia spends about US$11.5 million dollars on satellite data. Given the 7-year lifespan of the proposed satellite, Colombia would not recoup the cost of a US$250 million satellite in that time.[387]

The CCE functions as a governmental coordination body on space policy and research, thus it is classified as level one on the Space Technology Ladder. In 2011, the CCE released a white paper proposing a Colombian space agency, but no further action has been taken.[388] Since the university required assistance outside Colombia for acceptance testing, Colombia's efforts with *Libertad-1* meet the description for level five of the Space Technology Ladder; however, CubeSats are much less complex than larger LEO satellites. Colombia has no plans to procure a GEO satellite or launch capability.

C. ECUADOR

Like Brazil and Chile, Ecuador served as part of NASA's early satellite tracking network. In 1957, NASA established a tracking station in Cotopaxi, Ecuador and remained active until 1982. During this period Ecuador, through the Engineering Services Company (ESCO) supported manned spaceflight operations to the second flight of Space Shuttle *Colombia*.[389] NASA formally transferred control of the station to Ecuador in

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[386] Ibid.

[387] El Tiempo, "Frenan Compra de Satélite Que Vale US$ 250 Millones [Purchase of US$250 Million Satellite Stopped]]," September 15, 2014, http://www.eltiempo.com/politica/gobierno/gobierno-frena-compra-de-satelite/14533968.

[388] Comisión Colombiano del Espacio, "Documento de Recomendaciones Del Comité Técnico [Document of Recommendations of the Technical Committee]," September 2011, https://www.cce.gov.co:8543/alfrescocce-5.1.1.1/d/d/workspace/SpacesStore/cad627f9-42e6-11e2-8872-11f7c848c718/Documento_Recomendaciones_Comite_Tecnico.pdf.

[389] Engineering Services Company, "Pasado de ESCO [History of ESCO]," March 23, 2011, http://www.esco.com.ec/historia.htm.

1984.[390] After the handover, ESCO supported Ecuador's *Centro de Levantamientos Integrados de Recursos Naturales por Sensores Remotos* (Center for National Resource Extraction by Remote Sensing, CLIRSEN), which in turn supported the private petroleum industry in Ecuador.[391] On 19 July 2012, CLIRSEN became the *Instituto Espacial Equtoriano* (Ecuadorian Space Institute [IEE]), a military technical school similar to Brazil's IAE.[392] As in Brazil, the *Fuerza Aérea Ecuatoriana* (Ecuadorian Air Force [FAE]) plays a strong role in Ecuador's space program.

Ecuador's space program centers on Ronnie Nader Bello, a long-time space enthusiast and wholly unaffiliated with CLIRSEN or IEE. In 2006, Space Adventures, Ltd. announced that Nader reserved a suborbital flight through the company. This announcement has since been removed from the company website, but it was captured on a space enthusiast forum.[393] It is not know how this flight was to be funded. In conjunction with this flight, Nader Bello completed suborbital cosmonaut training at the Gagarin Cosmonaut training center in Russia; however, as of this writing, he has yet to complete his flight. Upon completion of this training, Nader Bello returned to Ecuador and, with the support of the FAE, founded the *Agencia Espacial Civil Ecuatoriana* (Ecuadorian Civilian Space Agency [EXA]) in 2007. EXA is a private non-profit company, owned in part by the FAE. The FAE also owns Ecuador's national airline TAME..[394]

EXA's lofty goals will not be realized before its mandate expires in 2019. EXA envisioned a three-phase program beginning with unmanned and manned suborbital flights, followed by an orbital flight to the ISS, and ending with a manned mission to the

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[390] Reuters, "Ecuador Satellite Station," *The New York Times*, January 5, 1984, sec. World, http://www.nytimes.com/1984/01/05/world/ecuador-satellite-station.html.

[391] Engineering Services Company, "Pasado de ESCO [History of ESCO]."

[392] Ecuador Inmediato, "Ejecutivo Crea Instituto Espacial Ecuatoriano Y Desaparece El CLIRSEN [Executive Order Creates Ecuadorian Space Institute and CLIRSEN Dissappears]," July 20, 2012, http://www.ecuadorinmediato.com/index.php?module=Noticias&func=news_user_view&id=177769.

[393] Jacques Edwin van Oene, "Space Adventures to Launch First Ecuadorian to Space," NASASpaceflight.com, August 25, 2006, http://forum.nasaspaceflight.com/index.php?topic=4018.0.

[394] Harding, *Space Policy in Developing Countries*, 159.

moon.[395] Even though these goals are far beyond Ecuador's ability to fund and execute, EXA has been successful in its educational outreach programs. EXA built a satellite ground tracking station and developed a server that allows researchers all over the world to communicate with their satellites when in range of Ecuador. Researchers from the University of Michigan were among its first users.[396]

Since its foundation, EXA has been involved in a variety of projects. In conjunction with the FAE, EXA conducts experiments in microgravity aboard a converted T-39 Saberliner donated by the FAE and designated *Fuerza-G Uno Cóndor*.[397] Currently, Nader Bello's son, Jules, holds the Guinness World Record for the youngest human to experience microgravity—he was seven-years old at the time.[398] Nader Bello and a team of four other engineers designed and fabricated Ecuador's first satellite, *Navio Espacial Ecuatoriano-1 Pegaso* (*Ecuadorian Spacship-1 Pegasus*, *NEE-1*). *NEE-1* also used the CubeSat architecture. The total costs of the project from design to launch cost roughly US$780,000. Ecuador provided US$700,000; the rest came from private donations.[399] The satellite successfully launched from the Jiuquan Satellite Launch Center in China on 25 April 2013. The satellite carried radio beacons as well as a video camera, which successfully transmitted images to EXA's ground station.

On 25 May 2013, *Pegaso* passed through the debris field of a Cyclone-3 upper stage launched in 1985. After the encounter, the ground team could no longer receive the satellite's transmissions or send commands, leading them to believe the satellite was tumbling. Argentina's *CubeBug-1* was a fellow passenger on the flight and also reported

[395] Agencia Espacial Civil Ecuatoriana, "Que Es El Programa Espacial Civil Ecuatoriana? [What Is the Ecuadorian Civilian Space Program]," accessed October 30, 2014, http://exa.ec/index.html.

[396] Agencia Espacial Civil Ecuatoriana, "Ecuadorian Civilian Space Agency Announces the Creation of the First Internet-to-Orbit Gateway," September 8, 2008, http://www.exa.ec/bp25/index-en.html.

[397] El Universo, "Avance Aeroespacial Ecuatoriano [Ecuadorian Aerospace Progresses]," *El Universo*, May 19, 2008, http://www.eluniverso.com/2008/05/19/0001/18/30321985CED443AFA2074379BB23FE99.html.

[398] Agencia Espacial Civil Ecuatoriana, "Ecuador Imposes First Guiness World Zero G Record," June 19, 2008, http://www.exa.ec/bp19/index-en.html.

[399] El Universo, "Fue Lanzado Al Espacio Pegaso, El Primer Satélite Ecuatoriano [Pegasus Was Launch to Sapce, the First Ecuadorian Satellite]," April 25, 2013, http://www.eluniverso.com/2013/04/25/1/1445/satelite-pegaso-hoy-alzara-vuelo-espacio-2313.html.

an anomaly.[400] On 21 November 2013, Ecuador's second satellite *NEE-2 Krysaor*, nearly identical to *Pegaso*, launched successfully from the Dombarovsky Cosmodrome aboard a Russian Dnepr rocket.[401] Not only did *Krysaor* function properly, on 27 January 2014 *Krysaor* detected the transmissions from *Pegaso* allowing ground controllers to recover the satellite.[402]

EXA challenges the definition of a space agency provided by Wood and Weigel. On one hand, EXA participates in space research and successfully developed two small satellites. On the other hand, EXA does not have the national political standing implied by Wood and Weigel. Consequently, this thesis does not classify EXA as a government space office or a national space program. While EXA has succeeded in several technical endeavors, EXA does not direct the formulation of space policy for the Ecuadorian government. This thesis does, however, credit Ecuador as having achieved level five on the Space Technology Ladder, given the strong financial support it receives from the FAE and the fact that Ecuador has embraced the accomplishments of EXA as its own. Although EXA carried out all the design and fabrication in house, it relied on labs in Holland to perform the acceptance testing, thus the effort resembles Colombia's effort with *Libertad-1*.[403] Ecuador continues its educational outreach program but has not yet announced any new projects.

D. URUGUAY

On 5 August 1975, Uruguay established the Centro de Investigación y Difusión Aeronaútico Espacial (Aerospace Research Dissemination Center [CIDA-E]), which to

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[400] Agencia Espacial Civil Ecuatoriana, "NEE-01 Pegaso Sobrevive Colisión Lateral Con Restos de Cohete Ruso [NEE-01 Pegasus Survives Lateral Collision with Debris from Russian Rocket]," May 23, 2013, http://exa.ec/index.html.

[401] El Universo, "Krysaor entró en órbita esta madrugada [Krysaor Entered Orbit this Morning]," November 21, 2013, http://www.eluniverso.com/noticias/2013/11/21/nota/1779801/krysaor-entro-orbita.

[402] Agencia Espacial Civil Ecuatoriana, "EXA Recupera El NEE-01 Pegaso Usando El NEE-02 Krysaor [EXA Recovers NEE-01 Pegasus Using NEE-02 Krysaor]," January 27, 2014, http://exa.ec/index.html.

[403] El Universo, "Fue Lanzado Al Espacio Pegaso."

this day focuses on space policy and promoting peaceful global norms in space.[404] In 1996, Uruguay hosted the third *Conferencia Espacial de las Américas* (Space Conference of the Americas). The second declaration from this conference encapsulates Uruguay's international orientation in space: "Reiterates and reaffirms the importance of continuing progress in the elaboration of norms that contribute to the development of international space law."[405] Uruguay epitomizes the constructivist approach to space.

In 2007, Uruguay's *Universidad de la República* began a collaboration with Antel, Uruguay's telecommunications company, to develop a small technology demonstrator satellite. *AntelSat* measures 20 x 10 x 10 centimeters and contains electronics for VHF, UHF, S-band communications, and a small camera payload. The satellite itself was one of 3 small satellite payloads aboard the Italian *Unisat-6*, which deployed *AntelSat* on orbit. *Unisat-6* and several other payloads were successfully launched aboard a Russian Dnepr rocket from the Dombarovsky Cosmodrome on 21 June 2014.[406]

According to the definition given by Wood and Weigel, Uruguay does not have a space agency; rather, CIDA-E is classified as a government space office. Like Colombia, Uruguay's efforts with *AntelSat* meet the description for level five of the technology ladder, with the caveat that the system was a CubeSat. Uruguay has not procured its own GEO satellite. Uruguay contracts its satellite telecommunications through Intelsat. In 2006, Uruguay agreed to cede its geostationary orbital slot to Venezuela in exchange for a 10 percent usage share in *VENESAT-1*.[407] Finally, Uruguay has no plans to develop launch capabilities.

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404 Dirección Nacional de Aviación Civil e Infraestrutura Espaciál, "Publicaciones [Publications]," accessed October 24, 2014, http://www.dinacia.gub.uy/comunidad-aeronautica/2013-11-12-18-16-59/centro-de-investigacion-y-difusion-aeronautico-espacial-cida-e/item/81-creacion-y-mision-y-funciones.html.

405 Eduardo Gaggero, "Space Policy-Making in the Americas," *Space Policy* 13, no. 2 (1997): 171–72, http://www.sciencedirect.com/science/article/pii/S0265964697000015.

406 El Pais, "Satélite AntelSat Pasó Por Cielo Uruguayo Y Empezó a Emitir Señales," June 21, 2014, http://www.elpais.com.uy/informacion/satelite-antel-sat-paso-cielo.html.

407 Acevedo et al., "Space Activities in the Bolivarian Republic of Venezuela," 178.

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